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REPORT
OF THE
PROVINCIAL INSTRUCTOR IN ROAD-MAKING,
ONTARIO.
—
1896.



REPORT
OF THE
PROVINCIAL INSTRUCTOR IN ROAD-MAKING
ONTARIO
1896.

(PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE.)

PRINTED BY ORDER OF
THE LEGISLATIVE ASSEMBLY OF ONTARIO.



TORONTO:
WARWICK BRO'S & RUTTER, PRINTERS, &C., 68 AND 70 FRONT ST. WEST.
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REPORT
OF THE
PROVINCIAL INSTRUCTOR IN ROAD-MAKING.

To the Honorable JOHN DRYDEN,
Minister of Agriculture :

SIR:—I herewith beg to submit to you my report for the year 1896 on Road and Street Improvement in Ontario.

The scope of this report is necessarily confined largely to a general review of the situation rather than a detailed statement of the work in which I have been engaged ; this for the reason that, my duties being of an educational nature, and the office having been created under an Order-in-Council bearing the recent date, April 15th, 1896, the period has been too brief to anticipate any radical effect upon methods which have held for nearly a century ; for the further reason that, while much literature relating to road improvement in England, France and the United States has been laid before the people of Ontario by the public press, little or none of a distinctly local character has been available, and a discussion of the subject in a manner applicable solely to this Province will therefore be of value and interest.

I have the honor to be,

Sir,

Your obedient servant,

A. W. CAMPBELL,
Provincial Instructor in Road-Making

DEPARTMENT OF AGRICULTURE,
TORONTO, Ontario, 23rd March, 1897.

PROVINCIAL INSTRUCTOR IN ROAD-MAKING.

INTRODUCTORY.

The improvement of roads in Ontario has not kept pace with the development of the Province in population, wealth, civilization nor commerce. This lack is seriously felt by all classes of society, and has, within the past three years, created an almost revolutionary movement in favor of better roads. Were economic methods instituted, millions of dollars would be added to agricultural values, and the mercantile and banking interests would be placed on a more stable basis. This movement is not confined to Ontario alone, of the Provinces of the Dominion, but is already beginning to take definite form in the others, especially Quebec, Nova Scotia and New Brunswick.

During my tenure of office, I have found the towns even more in need of reform in matters relating to street improvement, than are the rural communities, and they have been quite as ready to receive instruction. It should be understood throughout this report that streets of towns are quite distinct in very many particulars from country roads, and that the curbing, boulevarding, width of macadamized driveway and other features advocated for town streets are not applicable to township highways.

PROCEDURE.

In the performance of my duties, the procedure has been, upon receipt of a request for my services from a township, county, town or city council, to appoint a date upon which to visit the municipality. Accompanied usually by members of the council, the Board of Works, or a deputation, I drive over the roads or streets, and point out defects in their construction and maintenance. I further examine the material available for road-making, the system of expenditure, and the administration of road laws. Having made this investigation, and informed myself as to the lines along which reform is most needed, I deliver a public address on the subject, directing my remarks, however, more particularly to the members of the council. Subsequently I present to the council a written report upon the condition of the roads and streets examined, the material available, etc., etc., with recommendations as to the best methods and systems to be adopted. These local reports I find necessary in the great majority of instances. Oral instruction merely, particularly on technical points, is misconstrued, overlooked or forgotten to such an extent as to render a written statement of the greatest value in securing substantial results. They form also a record for succeeding councils. Two of these reports are appended to this volume, to show the ground covered by them—one for a town, and the other for a township municipality.

Municipalities visited in this way up to the end of 1896 were :

City of Stratford.

TOWNS AND VILLAGES.

Cobourg,	Orangeville,	Barrie,
Arnprior,	Brighton,	Port Hope,
Ingersoll,	Oarleton Place,	Cornwall,
Winchester,	Iroquois,	Morrisburg,
Pembroke,	Galt,	Newmarket,
Seaforth,	Clinton,	Woodstock,
Berlin,	Paisley,	Paris.

TOWNSHIPS.

Beckwith,	Hamilton,	York,
Matilda,	Mountain,	Winchester,
Williamsburg,	Finch,	Osnabruck,
Roxborough,	Cornwall,	Kenyon,
Charlottenburg,	Lochiel,	Lancaster,
Pembroke,	Tuckersmith,	Stanley,
North Norwich,	Cavan,	East Nissouri,
Elderslie,	Greenock,	East Zorra,
West Zorra,	Puslinch,	Hallowell.

INTEREST TAKEN.

In consulting with municipal councils, and in publicly discussing the question of road reform, the interest displayed has been most gratifying, and promises, in due time, the most satisfactory results. My attention has been directed to a number of instances of actual road construction in which improved methods have already been adopted with beneficial effect, as a result of the distribution of literature on the subject.

Public sentiment has been awakened with regard to the matter, and in every district of the Province I find the keenest interest taken in the discovery of ways and means whereby the neglected condition of roads and streets may be overcome. In every locality visited, my instruction has been met by an evident intention to carry it into practical use in the improvement of the highways.

MACHINERY EXHIBIT.

At the Industrial Fair, Toronto, in September, 1896, an exhibit of road-making machinery was arranged, and attracted a great amount of attention. It is intended to continue this exhibit in succeeding years, as it affords municipal officers and others interested in road-making an opportunity to learn not only the importance of using modern implements, but to see the different makes in actual operation, side by side, assisting in the selection of a pattern that will be most suited to their requirements.

MODEL STREETS.

Models of properly improved streets were constructed in Ingersoll and in Orangeville under my supervision.

BULLETINS.

Two bulletins were issued during the year, No. 1 being a brief pamphlet intended chiefly for pathmasters, while No. 2 contained a more carefully developed outline of the principles of construction.

STATUTE LABOR.

A consideration of road and street improvement naturally divides itself under two heads :

- (1) The system of expenditure and control.
- (2) The principles of construction.

With regard to the first of these, it is not the intention of this report to urge any alterations from present systems, but to define a proper administration of those already employed. With township roads, under this division, a consideration of statute labor and its reorganization is an important feature. It is almost universally admitted that, as at present administered, this method of collecting a road tax is ineffectual, wasteful and unjust, and that wherever an effort to put it on a business like basis fails, the only course is to replace it with a law which will render justice to all, and will produce better roads. If the endeavor to reorganize the statute labor fails to make it effectual in producing the class of roads required, the process will at least be one of education, and will lead to the substitution of a more desirable system.

STATUTE LABOR ABOLISHED OR COMMUTED.

The power to abolish the statute labor system is now in the hands of the people, and has been taken advantage of in at least one instance, that of Malden township, Essex County. The township of North Monaghan, Peterborough County, submitted a by-law to abolish statute labor in January, 1896, which was carried by a vote of 2 to 1 ; plans are now being framed to establish a new system throughout the entire municipality, statute labor having last year been done away with in only a part of the township. Other townships, in whole or in part, have substituted a system of compulsory commutation. As far as I have been able to learn, these townships are Winchester, Barton, Niagara, Sarawak.

COUNTY ROADS.

The County of Huron some years ago improved a considerable mileage of the leading roads of the county by the issue of debentures, the maintenance of these roads reverting to the townships through which they pass. The county of Hastings constructs and maintains a system of county roads, and the county of Wellington maintains several of the main roads by county grants.

PRINCIPLES OF CONSTRUCTION.

Dealing with the actual principles of construction with regard to township requirements, I have in this report enlarged chiefly upon gravel and broken stone roads, the material for these being generally distributed throughout the province. Drainage of roads, crowning the roads, judiciously locating them, width of roadbed, width of graded portion, treatment of hills, repairs, and machinery are among the principle subjects dwelt upon. With town streets, these details of construction require a more finished treatment to accord with the different surroundings and class of traffic.

TIRES.

The question of tires is a very important one, and calls for special emphasis. Were tires of a suitable width used in all cases, a very great part of the road question would be solved.

FURTHER TOPICS.

In addition, the necessity of giving attention to the appearance of country roads is dealt with, touching upon the relation of fences, trees, etc., to highways. A short historical sketch of some of the early and most important roads is included, dwelling chiefly upon the methods and means used, and the various influences affecting their development.

Much other useful and interesting information might have been included in this report, but it appears advisable to limit the contents to such subjects as seem most applicable to the present condition of the roads and the means available for their improvement.

THE ROAD PROBLEM.

There must be intelligent direction before there can be satisfactory results. It is becoming apparent to the people of the Province that improved highways are greatly needed; and the people are beginning to learn that they are suffering from a sore experience; that their labor has been largely wasted, and, in addition, large appropriations from the general municipal tax funds. The energy which has been, and is now being wasted, would, if properly applied, have each year extended, improved and maintained the highways proportionately with the growth and requirements of the Province in wealth, civilization and commerce. We would, if this energy had been properly guided, be now in possession of a system of roads such as would render a "Good Roads Movement" unnecessary. In their enthusiasm to effect a change there is a great danger of the people grasping at new systems and methods regarding which they are not as yet capable of forming a correct judgment, and which they are not yet qualified to carry into effect. Councillors are influenced by the effect of the agitation on the people, and, wishing to comply with popular demands, are of their own accord hurriedly framing and adopting new plans of raising money with which to carry on the work; such is the effect, but not the intention of the agitation.

The question of road reform is a great economic problem which must be approached slowly, and solved after mature and earnest consideration, based upon sound judgment and the greatest possible measure of experience. The great need of the present crisis, as has been stated, is intelligent direction, in order to avert experiments more costly and less productive of good than those from which the public are endeavoring to escape. There is an absolute necessity of providing municipal councillors, commissioners and the public generally with the fullest possible knowledge of the subject, otherwise there will be failure, discouragement and reaction. The history of roads dates back 1,000 years before the Christian era. In Canada, little better than a century is the sum of our experience. It is apparent that so young a country should look into the matter as presented by the history of roads in other countries to see at least if there is nothing to learn. It is contended that we have an immense mileage of roads, little traffic over them, and a comparatively sparse population, and that therefore the study of roads is something to be postponed until the country is wealthy and able to undertake the construction of highways in an expensive manner. All this is rather but a more potent reason why we should, as a country, conserve our energies and exercise them in the most judicious manner.

This, to a great extent, is more applicable to cities and towns than it is to rural districts. Some of the former to-day are already struggling under a load of debt, thrust upon them by unwise expenditure, by the adoption of wrong methods and by the use of material so unsuitable for street purposes that it has not endured one-half its estimated life. If the amount of money expended by these cities in their speculative efforts were aggregated the amount of waste would be appalling, and more so when it is understood that they are now looking for new material with which to experiment afresh. Climate, local geological conditions and requirements are all very similar throughout wide areas, and yet we have each town and city carrying on its own experiments in systems of taxation and construction, relying almost entirely upon its own experience, and meeting the failures that, with a reliable source of information, could have been avoided. It may be argued that one town can readily obtain information from another on application. This is not the case. Deputation are expensive, inefficient and opposed by the people. Clerks, treasurers and all municipal officers are reluctant or unable to give the necessary labor to correspondence regarding the matter.

In rural municipalities, each with conditions and requirements similar to the others, we have toll-road systems, county systems, statute labor systems, commutation of statute labor with direct taxation, direct taxation alone, plans of construction no man can number, describe or understand, embodying the peculiar notion of nearly every ratepayer who, in his turn, has at some time acted as road overseer.

The question is both very broad and very local. No one class of pavement can be clearly specified for all streets, and no one class of road can be adopted in rural districts, but these can all be divided into classes and placed before councils and the people in such a manner as to materially aid in proportioning pavements to requirements, and to the ability of the various communities. There are the country roads which are least travelled; there are those more heavily travelled leading to main highways; there are

the main highways which carry the traffic of extensive areas ; there is another class of roads most largely travelled of all, necessarily rare, which verge finally into the streets of large cities ; there are the streets of villages, of towns, of cities, all of varying requirements, regarding which the most reliable information should be procured. There are materials suitable for all classes of roads, and there are principles involved in the construction of pavements as with any other structure. Every building must be erected to meet certain requirements, and the nature of the structure and material used must be carefully balanced with the use to which it is put—strength, durability, service, in order to meet the requirements of economy, in all of which certain principles of construction must be observed.

There is too great a tendency to localize the question. The actual building of any section of road is a matter of an exceedingly local nature, but in obtaining the information from which to deduce both policy and specific details of construction there should be the most complete records upon which to draw. No city, town, township, county or province can afford to rely solely upon its own efforts, but each should be a source of experience for the other, and all should be able to draw upon the experience of other lands, past and present, to the fullest extent. There is a great deal of past experience on which to draw, but there is a more important present and future experience which should be indexed and made available for reference.

The data for determining the annual expenditure of money and labor on the streets and roads has never been collected with sufficient accuracy to permit a close statement of this element of our national taxation. Enough is known, however, to warrant the assertion that it is millions annually. Of this vast sum the greater part is wasted in ill-contrived and temporary repairs needed to keep the roads in a passable condition. In the present state of our taxation it is difficult to expect the people to impose a special tax to speedily improve country roads generally. It will be found that to attain the end in view the best plan is to assemble as far as possible the forces at work, concentrating the expenditure of money, and diverting to durable work as much as possible of that which is now paid for merely temporary repairs.

It is not to be inferred, nor can it be charged, that councils are less competent to deal with this than with other branches of public affairs. The difficulty is rather that the township councils have had too little to do with highway construction, and there is no person or body sufficiently responsible to the people for the condition of the roads. The most reasonable explanation of existing conditions is to be found in the little attention which has been paid to the effect and value of good roads. This in turn has permitted the administration of our laws to be neglected, and has not stimulated sufficient thought to develop an efficient organization of the ways and means available.

PART I.

COUNTRY ROADS

STATUTE LABOR.

The question of road reform has drawn attention to the statute labor system, the means by which a large percentage of the road mileage of this province has been built and maintained. Farmers' Institutes, Dairymen's Associations, Fruit Growers' and kindred associations, have everywhere discussed this phase of the road movement. It is undoubtedly the case that statute labor has done a great deal toward improving roads in Ontario since the first settlement. It is equally true that the system is entirely unsuited to the conditions found in populous and wealthy communities. It is incompatible with street improvement in cities, towns and villages, and it is urged that, in the long settled townships, the system has outlived its usefulness. It is undeniably the case that in some municipalities, the roads are to-day in a worse condition than they were ten years ago. While the pioneers knew the necessity of good roads and performed their work jealously, there is a sentiment beginning to prevail in certain sections and among the rising generations adverse to performing work on the public highways. Not only so, but those who perform work and those who have the direction of the work, are too frequently inclined to neglect and evade the true spirit of the system as it was exemplified by the early settlers. Where this neglect and evasion exists, not only do the roads interfere with the progress of the immediate locality, and therefore the country as a whole, but injustice arises in various ways between citizen and citizen, and between road division and road division. The citizen who performs his work, is taxed unequally with the ratepayer who is shiftless in its performance, while at the same time he is compelled to endure the inconvenience of a bad road. The section or road division, which does good work on the highways is unjustly treated by the neighboring division which does not do its legitimate work; the further probability is that the division which has failed to perform its work will find it necessary to obtain municipal money grants, thereby placing on the neighboring division a double tax.

A plan whereby the work of road improvement and maintenance may be carried on in a business like way is a subject that many councils are considering. It is well-known that in most municipalities there are no particular plans, other than those which suggest themselves as the work becomes necessary. Many councils are now considering better systems of road improvement and maintenance, but unless these systems are put into operation on business like principles, the result will be inferior work and increased taxation.

A SUPERVISOR.

The direction and oversight of municipal improvements should be placed in the hands of a supervisor who should be a man specially adapted to the work, and whose tenure of office should be as secure as that of the average clerk or treasurer. The supervisor should have charge of all road and bridge improvement, and should be required to report to the council at each meeting; no work should be undertaken until it has been reported upon by him and approved by the council. He would not necessarily be actively engaged during the whole year. He should have charge of all township machinery and material required in the work connected with this department. The many economics that would result will readily suggest themselves to councillors of experience.

PATHMASTERS.

Road divisions or "beats" should be from three to five miles in length. A pathmaster should be a permanent officer, and his division should be such that the most of his travel will lead him over the greatest portion of it. He should not receive a salary, but should, as a slight recompense, be preferred in doing small jobs under the supervisor, where the work is not considered of sufficient importance to be let by contract. He should, in addition, give special attention to all emergency work, such as washouts, broken culverts and bridges. If the time required to oversee statute labor in his division is more than would be needed for his own statute labor, he should be paid for such excess under certificate of the supervisor or council, the object being to secure proper supervision of all work performed; the council or supervisor to determine whether the excess time was actually necessary to oversee the work of the division, in accordance with the local by-law of rules and regulations, which should be framed so as to include this matter.

DUTIES OF SUPERVISOR.

1st. The supervisor should prepare a plan of his district, or township, showing all roads, and the location on them of all culverts, bridges and watercourses, classifying roads according to their requirements.

2nd. He should prepare a list of all culverts and bridges, showing dimensions, material used in construction, their condition and the direction of the watercourses passing through them, with memoranda as to the course of the water and location of the outlet.

3rd. The plans and records should show, as to roads, whether they are of gravel, stone or earth, graded or ungraded, the system of drainage, and nature and extent of traffic upon them. He should carefully study the present and future requirements of traffic on all roads, the class of roads best suited to such traffic, the width and depth of metal, width of graded portion, amount of crown and other details of construction.

4th. He should possess full information as to location, extent and quality of material suitable for road construction, and amount of plank and timber obtainable from ratepayers in the township or district, suitable for repairs.

5th. He should report to the council as early as possible in each year, showing the number and location of culverts and small bridges to be re-built or repaired, with a detailed statement of all material required for this work, and an estimate of the cost. It would also be advantageous to have a probable estimate of material required during the following year, presented each fall so that, if thought advisable, it may be purchased and delivered on the ground during winter months or other most convenient season, so as to utilize as much as possible the labor of ratepayers during the slack season.

6th. His report should specify the condition of all bridges, indicating those which require repairs or reconstruction, together with an estimate of cost, and a statement dealing with such special protection work on streams as he may deem worth the council's consideration. There should also be reference to any needed re-location or deviation of existing roads with a view to doing away with bridges, culverts, expensive grades, cuts or other features which tend to prevent permanent work and economic maintenance.

7th. He should consult with all pathmasters and report to the council, showing the number of days labor in each division, the work to be undertaken, and the amount of money which should be appropriated by the council to properly utilize the statute labor.

8th. He should arrange with divisions desiring to compound statute labor for a term of years, with a view to the construction of permanent and finished work.

9th. He should take stock annually, and report to council on all machinery and implements, showing their condition and where kept.

10th. He should carefully examine all parts of the township where gravel and stone exist, and should by borings and tests, determine the quality and extent, and report thereon to the council. All material, stone, plank, gravel, etc., should be purchased by the supervisor in large quantities, and under instructions from the council, the required amount to be determined by his estimates referred to above. As far as possible the material should be purchased by tender, and due consideration should be given to any ratepayer having material for sale. When purchased it should be delivered and stored at convenient points, and placed in charge of, and used by the pathmaster, subject to the order of the supervisor, and in emergency work.

11th. He should prepare specifications of all work for which the council makes appropriations. Contracts should be awarded to the lowest bidder if proper security is given, but the work should be subject to the approval of the supervisor and all accounts should be certified by him before payment.

A municipality is merely a business corporation, the people its stockholders, the councils its board of directors and the officials the managing staff. If as much attention were paid to the management of a municipality as is devoted to a business enterprise of similar proportions, economy in many directions would follow. No business enterprise could afford to change its board of directors or manager each year, intrusting its affairs to an inexperienced executive.

COMMUTED STATUTE LABOR.

The commutation of statute labor is a system of taxation for road purposes which has been adopted in several municipalities, and is said to operate with a considerable measure of success. The assessment is based upon the statute labor list, the rate being fixed by a local by-law. The usual rate is fifty cents per day. In Barton township the rate is fixed annually according to the total expenditure for the year, and ranges from thirty-five cents to fifty cents per day. It is to be pointed out, nevertheless that, with commutation, pathmasters are still appointed, an amount proportionate to the labor on a beat being given to each pathmaster. Proper supervision of the work is as necessary under a system of money expenditure as with statute labor alone; and it is, therefore, quite as important in the one case as in the other to follow the suggestions for a proper organization of the statute labor system as to reducing the number of pathmasters and appointing a general township supervisor.

STATUTE LABOR ABOLISHED.

The township of Malden, Essex county, is the only township municipality which has yet completely abolished the statute labor system. The change was made in March, 1890. There are about sixty-five miles of road in the township. The total mileage is graded and about two-thirds is metalled with gravel or crushed stone. The township Clerk, Mr. James Honor, in response to an inquiry regarding the change says:—

“We have a perfect system of doing roadwork. Whole concessions are ditched and gravelled. Water is carried until it reaches its proper outlet. No one is allowed to suffer by water being thrown in front of his farm and left there until the next road overseer is appointed to take it off. All work is done in a thorough, systematic and business-like manner. It is let by contract, superintended and received by our council. The change operates successfully and there seems to be no disposition on the part of any ratepayer to return to the old system. The cost of road improvement is paid out of the general township funds, and the amount spent on the roads annually for the past five years was about \$2,000 a year.

“The cause of the change was the corrupt and expensive manner in which statute labor was done. For a number of years previous to 1890 we had commutation of statute labor at fifty cents a day, which worked fairly well for a time until the applicants seemed

to have got all the work done that they required around their farms. At the same time, our township was divided into seventeen road divisions, and seventeen prominent farmers got this statute labor given them for superintending the work that was not commuted. Each one had his peculiar views about doing road work, selfish motives, cranky notions, and occasionally no ideas at all. Some favored doing the work in the spring and some in the fall; some spread the earth on the road and piled the gravel on top of it; some put on gravel and placed dirt alongside to keep it there.

A township that has good roads, well drained and gravelled, shows a higher state of civilization and taste than one that has not. Consequently a practical man would rather locate in our township than in the neighboring ones and the price of farm land seems to have kept up as compared with other townships."

EXISTING ROADS.

The roads of most townships naturally divide themselves into three classes. The first and least important are those cross roads and little used concession roads which accommodate only a few farms; about three-eighths of the road mileage will fall into this class. In the second and more important groups are those which serve a considerable neighborhood, and comprise, usually, about three-eighths of the road mileage. The third group consists of the main roads which concern the community as a whole and these in some townships merge finally into the streets of large market towns and cities; to this last division will belong nearly the remaining quarter of the road mileage. It is the roads of this last group which, in some instances have, in Ontario, been taken over and constructed as county roads.

It is apparent that each of these three classes have different requirements. Over the first class, the least travelled of all, half a dozen or a dozen vehicles going in one direction may be the average traffic for one day. The neighborhood roads may be called upon to accommodate twenty or thirty vehicles; over the main roads the number of vehicles daily may range from fifty to two hundred. To provide the same strength of construction in each case, would manifestly be either inadequate for the most heavily travelled roads or unnecessarily expensive in the case of the first group mentioned. Those which accommodate the greatest amount of traffic, it is apparent, will need the strongest form of construction, and on them should be concentrated as far as practicable, the money appropriations made by the municipal councils.

To the first group will necessarily belong the dirt roads. These will be gradually gravelled, but it cannot be expected, for a number of years to come, that much expenditure of labor or money can be made on them. The little wear to which they are subjected, however, rendering their maintenance very simple, will make the time required for their improvement comparatively short. These dirt roads are very much abused by the road-makers. With each annual application of statute labor, sod, vegetable mould, and stones, are brought to the centre of the road, to be mixed up into mud with the first fall rains. For six months of the year, a dirt road, (not a clay) is as good a driveway as could be desired for light travel. But in order to extend its usefulness, the greatest care must be taken to see that drains and culverts are placed wherever needed, and that they are always in good working order. It should be well crowned, or rounded up, so as to shed the water freely to the side ditches; but in making this crown, sod and vegetable mould should be carefully excluded. A great deal of injury is done to this kind of road, by running a grading machine along the edges, bringing loose stones and sod to the centre. This stuff should be thrown outward and across the open drain. Under drains should be used judiciously; while a complete system may not be used, tile drains should at least be placed where the water does not leave the side of the road early in the spring, or wherever the ground appears to be continually damp. If open drains are kept in good working order, and if the road is kept properly crowned, its condition in fall and spring will indicate the points at which tile drainage is most needed.

Nearly all roads in Ontario have at one time been mere dirt roads. By a slow process of evolution some have become gravel or broken stone roads. These gravel roads are the highways which will fall into the second and third groups indicated in a preceding section of this article. A dirt road nicely crowned and well drained will make an excellent foundation on which to place a layer of gravel. A driveway which has passed through an apprenticeship as a dirt road, and has, during that time, had due attention given to its drainage requirements, will have indicated the points at which open drains, culverts and underdrains are most needed. With these provided, gravel can be applied to the best advantage.

The object in placing a coating of gravel on a dirt road is not merely to form a hard wearing surface, nor is it to change the consistency of the mud. A coating of gravel or broken stone is placed on a road to form a covering that will not permit water to pass into the earth subsoil, and which will not permit the forming of ruts that will hold water. Unless the dirt road beneath the gravel has been provided with drainage deep enough to secure a good firm foundation, the gravel will sink beneath the wheels, ruts will form and the road will be destroyed.

Very few existing gravel roads show a proper conception of the principles of road-making. The majority are too flat on top to shed the water. The sides of the road form square shoulders which obstruct the water in passing to the surface drains. Open drains are often deep and dangerous, but are not provided with proper outlets. If drains are merely receptacles for water, the subsoil of the roadway absorbs this moisture, is softened, and in the wet weather of fall and spring, traffic forces the gravel covering downward, and the mud to the surface, mixing the gravel and soil to such an extent as to very much destroy the usefulness of the road covering.

As with dirt roads, a great mistake is made by passing a grader along the shoulders of a gravel road, to cut off the shoulders, bringing the loosened material into the centre to round up the roadway. If a portion of the shoulders happens to consist of clean gravel, this may be replaced on the hardened track of the road. But as a rule the shoulders are composed of fine stuff, sand, dirt, loose stones and sod, and is of the greatest injury to the roadway. This stuff is of such a nature as to at once roughen the road, while in wet weather it absorbs water, becomes soft and slushy, and ruins the hard gravel foundation underneath. The material composing these shoulders should be thrown outward across the open drains, and used in levelling the roadside, or it should be otherwise disposed of in such a manner that it will at least not injure the roadway. When these shoulders have been cut off, it will be advisable to pass the road scraper over the centre to take away as much fine stuff, and loose stones as possible; and on this a new layer of gravel or broken stone may be placed to complete the crown of the road.

The drainage usually found on existing roads consists of open ditches on each side of the graded portion, with a depth of about eighteen inches. They are frequently carried through rises of ground past natural watercourses. Little attention is given to the regularity of the grade in the bottom, nor to the amount of fall, as evidenced by the varying depths of stagnant water at wet seasons. The object of these drains was more to procure earth to raise the centre of the road above the water line than to lower that line. The secret of successful drainage is to dispose of water in small quantities before it gains force and headway; and for that reason it should be carried past natural watercourses as seldom as possible.

The best practice does not direct that the old open drains should be deepened for the purpose of draining the subsoil. Deep open drains are expensive, dangerous and unsightly, and the excavated earth generally does more harm than good to the road when used to round it up, especially if piled on top of gravel. When the combined cost of construction and maintenance is considered, a small tile drain laid under the bottom of each open drain is cheaper and more serviceable. It is believed by some that one tile drain placed in the centre of the grade is the better plan. In the case of an old road with a hard surface this is very difficult and expensive, and the roadbed, if metal has been used, is destroyed by so doing. If any obstruction occurs with one central drain, in

order to locate and remove the cause of the difficulty, the roadbed must be broken up, sometimes extensively. Where side drains are constructed, they not only drain the foundation, but they protect it by intercepting the soakage water from the adjacent land. Where open drains exist, as they do on the majority of roads, the cost of excavating for the two underdrains is lessened, and smaller tile may be used. Outlets can easily be had into the tile drains for surface water from the ditches, by the use of catch-basins when necessary, and this is rendered more simple when two tile drains are used.

The success of a drain largely depends upon its outlets. Frequently its usefulness is largely removed if not entirely destroyed by the imperfect outlets on private property, the result of the opposition of the landowner, and the dislike of the municipal council to invoke the aid of the Municipal Act to enforce its construction. A drain without an outlet is useless.

ROAD METAL.

GRAVEL.

The majority of roads in the province which have received a surface covering, are metalled with gravel. It is very plentiful, and where it is to be obtained within easy hauling distance is undoubtedly a most valuable material for use on most country roads, and on many of the little travelled residential streets of towns. In localities where gravel is not within easy hauling distance, however, it will be advisable to consider the use of other metal; since gravel, if not found in the immediate locality, and therefore expensive in transportation, will frequently be found less economical in final cost than a better, though higher priced stone. Gravel may be described as a mass composed of fragments of stone, rounded and worn by the action of air, water and ice, the pebbles representing the hardest bits of the rock from which they were detached. With it, is commonly mingled a variably quantity of boulders, sand, clay and earthy matter.

The rounded, water-worn character of the pebbles composing the gravel, does not permit as perfect a bond as is the case with a road covering of crushed stone, in which the sharp angular sides take a firm, mechanical clasp. Gravel has not very satisfactory wearing qualities, especially when it contains an excessive amount of earthy matter. Where much sand and clay is contained, it should be removed by screening, and the large stones and boulders should be broken. If there is a large proportion of the latter, a method which offers many advantages is to place a rock crusher with a rotary screen attachment in the pit, passing all the material through, thereby removing the earthy substances, and breaking the stone with the one operation. If the number of large stones is not great, it will be the cheaper plan to screen the gravel in the ordinary way or, better, by a rotary screen propelled by steam, the large stones being broken by hand or used in the road foundation.

When being prepared for use on heavily travelled and important roads, care should be taken to remove the dirt from the gravel. Sand and clay, when mixed with gravel afford an easy means of consolidating the road covering in such a way as to be very suitable for traffic in dry weather. But in wet weather, moisture is absorbed, the roadway becomes soft and slushy, ruts form readily, and the bond will be found of a very temporary nature. For little travelled roads, it may be impossible to take the precaution to screen the gravel; and perhaps if the earthy matter is not in excess, screening may be omitted to advantage; it is necessary, however, to emphasize the point that this can be recommended for little travelled roads only.

When gravel is not screened, very much may be accomplished, by care in selecting and taking it from the pit. In drawing gravel to the roads, it is frequently the case that teamsters wish to be in company with each other as much as possible. For this reason, when loading the gravel, while there may be room for only one wagon, in the pit, at the point where the best material is to be found, a dozen teams will drive in, and

the wagons are filled with whatever stuff may be most easily obtained, whether gravel, sand, boulders or clay. Another common cause of earthy matter and sod being mixed with the gravel, is to be found in the practice of tunnelling under an overlying layer of soil which gradually falls into the pit, is mixed with the metal, and is drawn with it to the road. This earth should first be stripped from the surface if it does not form too deep a strata, or care should be taken as it falls to keep it from mixing with the gravel.

In the district formed by the angle of the Ottawa and St. Lawrence Rivers, and a line extending northerly from the vicinity of Kingston, the surface is composed largely of glacial drift or "till," while in some portions of this section, bedrock appears at the surface. Gravel is not very plentiful, but that which does occur is of a hard quality, the waste of trappean rocks, contains little clay and is sometimes comparatively free from sand. It is to be looked for, usually, in narrow ridges and mounds formed in the tunnels and caves of ice, through which were the courses of sub-glacial streams. Occasionally in this district, more especially the easterly portion, lake deposits of the post-glacial age are to be found in stratified layers.

Westerly from Kingston and south of Georgian Bay, the glacial waste is overlaid to a greater extent by lacustrine deposits, of which the chief stratas are the Erie and Saugeen clays. Inter-stratified with these, and in drifts and pockets, gravel is to be found at frequent intervals. The quality, however, is not equal to that of the eastern district, being composed more largely of the waste of the local limestone strata. It is of a soft "cement" variety, and has considerable clay and sand mixed with it. Along the base of the Niagara escarpment from Owen Sound to Brantford, there is a remarkable bed known as Artemesia gravel, having an average width of about twenty three miles, and a considerable depth. This extends easterly also, following the north shore of Lake Ontario, in what is known as the Oak Ridge. While this formation of gravel is comparatively free from earthy matter, it contains a quantity of large stones and boulders which interfere with it as road metal. It is principally composed of the water-worn debris of the Niagara and Guelph limestones, mixed with which are some pebbles and boulders of trappean origin.

In searching for gravel, the clearest indications are usually to be found along the banks of streams, where any extensive strata is apt to be exposed. A post-hole auger affords a convenient means of making tests over the surface of the soil for gravel, but the best implement is generally a simple form of drill. There are cases in which gravel beds may be entered at the level of a stream bed, and water is thereby obtained for washing the metal by natural drainage, affording a cheaper means of freeing it from sand and earthy matter than by screening. Gravel is still being deposited in drifts and bars by the agency of streams; this will be found to partake of the character of the pit gravel of the locality but generally will contain less clay, although sand may easily be in excess. This is usually one of the best sources, as the gravel can be washed by natural drainage. Lake gravel is often a good metal but varies greatly. It is apt to be slaty, an undesirable quality. It will be free from dirt and clay, but contains sufficient sharp sand to secure consolidation, especially if a roller is used. Gravel which retains a perpendicular face in the pit in spring, and shows no trace of slipping when thawing out may generally be assumed to be sufficiently clean and free from clay for use on the road without any treatment other than is necessary to remove stones greater than one inch and a quarter in diameter.

BROKEN STONE.

It is impossible to discuss the wearing qualities of different kinds of stone for macadam roads from the standpoint of names. Granite, limestone, sandstone, are names of different rocks common in this province, but to say that granite is better than limestone, or that limestone is better than sandstone, while true, perhaps, of the best qualities of each, may be quite incorrect, since a good sandstone may be infinitely preferable to a poor limestone or granite. The best stone for a macadam road is that which is hard and tough, not easily affected by the atmosphere, moisture, and the varying conditions of

climate. The choice will generally lie between a cheaper and less durable stone near at hand, and a more costly but better stone from a distance. The city of Cleveland, Ohio, is for example importing trap rock from Poole Island near Bruce Mines, on the north shore of Lake Superior. This rock is very hard, tough, and for qualities of endurance can scarcely be surpassed on the continent.

A great portion of macadam roads in Ontario will be constructed of limestone, since this rock is the most common, quarries being within easy access of almost any part of the province. In quality it ranges from that which is useless to that which is almost equal to trap. Limestone which is tough and closegrained, is an excellent material for roads on which the weight of traffic is not excessive. Some dolomitic limestones, while hard, appear to lack in toughness. Other limestones of a slaty texture have few wearing qualities, are rapidly disintegrated on exposure to the atmosphere, and should be avoided. Some limestones of an open, porous nature, yield readily in this climate to the effects of moisture and frost, merely turning into mud. But the excellent binding qualities of limestone make up largely for a lack of hardness, a sort of cement being formed by the dust, which adds very much to its durability.

Some qualities of granite rank high, but much of it will crumble readily, and wear into sand. It is to be had in many parts of northern Ontario, and could be easily reached by boat or rail. Except when the traffic is unusually heavy on the road to be paved, and the best granite is obtained, the cost of transportation will debar it from use in the greater portion of Ontario. Gneiss, like the granite, occurs in vast quantities in the northern districts, and is of variable quality. That containing much felspar or mica is the least desirable. Sandstone is seldom of service, except when used for very light traffic on country roads, since it also readily crumbles and wears to sand. It is quarried chiefly at the Forks of the Credit.

Limestone is quarried very largely at Queenston, at Hagersville and other points along the Grand river, at Kingston, and the counties east; granite is obtainable in the more northern part of the province. Trap rock occurs in dikes of considerable proportions near Kingston and Gananoque.

In determining the best quality of stone for road purposes, there are four prominent destructive agencies which have to be considered: (1) The crushing action of loads. (2) The grinding action of the wheels. (3) The blows from the shoes of horses. (4) Climatic influences of air, water and frost.

With respect to the first three, a stone may have great hardness and splendid crushing strength, but at the same time be brittle, yielding readily to the grinding effect of wheels, and the blows administered by the hoofs of horses. On the other hand, a stone may be able to resist, in a measure, the second two wearing agencies, those of "abrasion" and "impact," and yet be so soft as to crush readily.

The fourth agency, the decomposing effect of the atmosphere, is one of very great importance. The denser stones, those which absorb the least water, are usually best able to resist the injurious action of frost and moisture. The weight of a stone is usually some indication of durability in this respect, the lighter stones being those of less density, and in consequence are the less desirable.

There are other features which a good rock for road-making should possess. When crushed they should break into a compact form. A stone that, in breaking, takes thin, flakey shapes, will not wear so long as one that breaks into cubical pieces, nor will it consolidate so readily in a roadbed, for a wheel, in passing over the side of a flat stone, will throw it out of place and loosen the stones adjoining.

The tests usually applied in determining the qualities of stone are those which indicate crushing strength; the power to resist impact and abrasion; the density, determined by the weight of the stone; the amount of water absorbed. While elaborate trials may be made, a practical man can judge of the qualities of a stone by applying simple tests; by breaking the stone with a hammer; wearing it on a grindstone; crushing it in a black-

smith's vice ; scratching with an iron nail ; breaking small pieces with the fingers. By such simple means, a general idea of the stone can readily be formed, but no test is conclusive except actual wear on the road, for varying local conditions, lead to varying results.

BOULDERS.

Broken stone produced from boulders is objected to as road metal on various grounds. The rounded sides will not permit consolidation with the minimum of vacuum. If they have been exposed to the atmosphere the boulders are very apt to be decomposed, are soft and will crumble readily. The mixture of different kinds of rock on the road surface, some hard some soft, permits unequal wear, and produces a rough surface.

While these are defects which certainly are not to be overlooked in the choice of road metal, boulders nevertheless, constitute a very valuable material for the construction of a road, particularly in localities where they are plentiful and gravel or bed rock not readily obtainable.

Boulders are generally the result of glacial action. A large portion of the province is overlaid with "till" ; that is, a mixture of boulders, clay and pebbles in varying proportions, brought down by the rivers of ice, and left in a broad irregularly disposed sheet, as the ice melted. In some instances, the retreat of the ice, as the glacial age passed away, was interrupted by pauses and readvances. This created the frontal moraines or ridges of debris pushed out by the glacier and deposited along its front. Subsequently the inland lakes and rivers which have been obliterated by upheavals of the earth's surface, together with lakes and rivers now existing have covered up much of the material and acted upon the glacier waste in many ways. The rain also, washing away the earthy material supporting boulders on the hill tops, has left them exposed, or permitted them to roll to the valleys below.

Frequently these frontal moraines are distinct features of the landscape, as is the case between the southern portion Hastings County and Georgian Bay, where they appear as rough stony hills. In other cases they form merely indications on the surface of the ground, the moraine having been covered with a later deposit of fine stuff. As a rule, the moraines are better sources of road metal than the till, since in the former case there is a less quantity of clay and sand intermingled ; while the boulders taken directly from the till or moraines are generally of a better quality than those at the surface of the ground, which have been exposed to the action of the atmosphere.

The majority of the boulders to be found in Ontario are of Huronian or Laurentian origin ; that is, rocks of gneiss, trap and granite brought down by the glacial rivers from the distant north easterly from Georgian Bay. In some parts, rocks of local origin are to be found, notably in the counties of Glengarry and Wellington, where considerable quantities of limestone are exposed.

In selecting field boulders, care should be taken to discard all rock which shows signs of having "weathered," or decomposed by the action of the atmosphere. Sandstones and granites are peculiarly subject to this disintegration, while soft limestones are very common. Rocks which should be condemned from this cause are those which crumble readily under successive blows of a hammer, or which show iron stains when broken. A little experience will quickly teach a judicious roadman to detect the stone which is unfit for road purposes.

PLACING METAL ON THE ROADS.

In order to obtain a knowledge of the manner in which gravel, broken stone or other road metal should be placed on the roadway, it is evidently necessary to consider the objects to be attained by the use of a surface covering. Experience teaches us that these are :

- (1) To prevent water entering and softening the natural soil beneath.
- (2) To present a hard and durable wearing surface, sufficiently smooth to make travel and the transportation of heavy loads, easy and agreeable.

According to the first of these objects, the covering must be of such a texture as to be as far as possible impenetrable to water, and of such a shape as to shed the water to the side gutters or ditches. According to the second, the road covering must partake of the character of a floor. In summer and in dry weather, a road made of the natural soil, if not sand, is a satisfactory driveway for moderate traffic. It is to make a good wet weather road, that metal is usually applied. If the work done on the road is not successful in producing this, the efforts have either been inadequate or misapplied.

The customary way of putting gravel and broken stone on the road is to merely drop the metal from the wagon, leaving it, as it falls, in a continuation of irregular heaps, to be levelled and consolidated by traffic. This metal is usually placed on the road in June. Vehicles at once turn away from it and find a more serviceable dirt drive along the side of the road or in the gutters. Traffic continues to follow the dirt roadway until such a time, late in the fall, when it has become rutted and muddy. Not until forced to do so by the impassable condition of the dirt track, do vehicles turn to the metalled portion. If this dirt track is between the metal and the ditch, the ruts and holes will interfere with surface drainage ; will prevent the water reaching the ditch quickly from the crown ; will be receptacles for a large amount of water. In soaking away, this water will pass under the gravelled portion, and assist in softening the natural sub-soil which, in a well made road, must be sufficiently dry and firm to support the weight of traffic. The gravel or stone lying loosely on the road, has permitted water to pass through it to the natural soil below, as through a sieve. The first effect of wheels passing over it is to create ruts in the metal itself. These ruts in turn become receptacles to hold water, the gravel in the ruts is quickly forced aside and downward, and the wheels sink as far as the mud will permit them. Winter may freeze the ground, and afford a firm means of travel during the frosty season, but when the weather breaks up in the spring, the roadway, upheaved and honey-combed by the ice which formed in and below it, is many times worse than in the fall.

It is evident that to drop gravel, and especially broken stone, loosely on the road is very far from being an economical system of roadmaking. The summer succeeding the application, the road, after the ruts are worn down, may become a good driveway ; yet the gravel or broken stone has been so churned, and mixed with dirt, that its life and durability have been largely wasted before it becomes sufficiently compact to answer the purpose for which it was intended.

A great deal, by very simple means, can be done towards getting better results from the road covering. The metal when first placed on the road could be nicely spread with a rounded surface, as it is intended to lie when consolidated. The metal, particularly if gravel, will, during the summer, consolidate much better than if left in a high heap. In the fall it will be harder, and, not presenting so formidable an obstacle to travel as a series of irregular mounds through which the horses must wade, vehicles will turn from the temporary dirt tracks earlier in the season, before the subsoil has become very soft. If at this period a man is sent along the road, with a rake to fill up the wheel tracks as they appear in the loose gravel, or broken stone, traffic will, in a short time, very effectually consolidate the road. The expense of a man in raking the metal into the ruts and keeping the road properly rounded up during the fall and spring, will be more than saved in the future repair and re-metalling, while a much better road will be the result.

ROLLING COUNTRY ROADS.

Although much can be done by the use of a rake, to assist traffic in consolidating the metal, as indicated in the preceeding article, "Placing Metal on the Roads," the road, nevertheless, should be made for traffic, not by it. A much better plan is the use of a road roller, the advantages derived from which are several :

(1) A good track is immediately obtained, and vehicles at once take the centre of the road.

(2) A dirt track is not made near the ditch, and, by this means, the side of the road is not cut up and made so uneven as to interfere with surface drainage.

(3) Traffic is not inconvenienced in fall by having to drive through loose gravel or crushed stone.

(4) The gravel or stone is not forced down into the sub-soil by the wheels and feet of the horses ; is not churned and mixed with the earth, and there is in this way a great saving in the amount of metal.

(5) There is a great saving in manual labor, and repairs are more easily and effectually made.

An impediment to the use of heavy rollers in a good many townships, is the insufficient strength of bridges, and culverts ; and, while valid in some instances, the objection is liable to exaggeration in others. Weak wooden bridges and culverts could in many cases be temporarily strengthened sufficiently ; while in others, they could be entirely avoided by first completing the rolling on one side, and then passing around a block or so, to commence work on the other.

It is not probable that many townships councils will find themselves in a position to purchase a roller for the exclusive use of one township. In England, the county councils usually undertake this measure. If this were done in Ontario, the roller could be rented to the townships for use on the main roads. Other townships are so situated that they could rent from towns in the vicinity which own a roller. Or, as suggested in discussing stone crushers, a private citizen could be induced to purchase the roller under proper assurance of employment. When the benefit to be derived from the use of rollers is better understood they will be more generally adopted.

DRAINAGE OF MACADAM ROADS.

A prevailing impression with respect to macadam roads is that an allowance which has had the centre portion raised and levelled, with open trenches at the side, and a layer of gravel loosely dropped on the graded portion, has been macadamized. This is very far removed indeed from the principles laid down by Macadam, the principles which have changed the roads of England from a state of impassibility to a condition of excellence, unsurpassed by any in the world.

Macadam insisted upon the theory that it is the native soil which really supports the weight of traffic ; that while it is preserved in a dry state, it will carry any weight without sinking, and that it does, in fact carry the road and carriage also ; that this native soil must previously be made quite dry, and a covering impenetrable to rain must be placed over it when in this dry state. To the erroneous opinion long acted upon, that, by placing large stones in the road bed and covering them with smaller metal, although the sub-soil was in a soft, wet state, a good road could be made, he attributed the bad condition of most of the roads of Great Britain. The first requisite of a macadam road is drainage.

Subject as we are, to continued autumn rains, followed by a period of severe frost and snow, with the attendant thawing and flooding of spring, it becomes of prime necessity that, in Ontario, drainage must be as perfect as possible. So little is the truth of

this recognized that a drive along not only our country, but many of our city and town roads, would lead one to think that to get the water into the road and to keep it there is the idea of our road-makers.

Underdrainage, except in very rare cases, is entirely ignored. Surface drainage generally consists in heaping up a driveway in the centre of the road allowance, covering this with a loose coating of gravel, and leaving the excavations at the side of the roadway thus formed to hold water, since, although called "drains," they seldom have outlets. The water held in these trenches soaks into and softens the foundation of the roadbed until there is a sort of floating island.

To remedy this state of affairs, gravel is, by our road-makers, continually heaped on in the hope of in same way covering the water and corking up the mud. This is a very expensive and unsatisfactory method of roadmaking. Underdrains of common field tile (provided with outlets) to "lower the water line;" and open drains or gutters (also provided with outlets), to carry away surface water, are the practical means of creating a foundation for a road. With a soft, wet, yielding foundation, a road is no more durable than any other structure under similar conditions.

Any thoughtful farmer who knows the effect of underdraining in his fields will at once recognize its usefulness in road-making. In the fall, water will be rapidly removed from the bed of the road and the destructive action of frost lessened. In the spring, the frost will come out of the ground more quickly, and each of those periods in fall and spring are shortened, when, with the foundation and surface thoroughly saturated, the roads are not only impassable on account of the mud, but are injured by traffic more than in all the remaining nine or ten months of the year. One year's statute labor with the annual appropriation, spent in providing proper drains for the roads of the province would do more than can be done in five years with the present method of merely filling the holes which appear, with gravel or crushed stone.

Underdraining and grading should be carried on simultaneously. Unless drained, the traffic during the ensuing autumn and spring will usually leave a graded road as shapeless and rough as a pioneer wagon track can be. If drained, there will be a foundation for the gravel or crushed stone to rest on when applied.

A porous soil, like a sponge, retains in its texture, by attraction, a certain amount of water. When water in excess of this is added, it sinks to the first impenetrable strata, and from there it rises higher and higher until it finds a lateral outlet; just as water poured into a pail will rise higher and higher until it finds an outlet in the side of the pail, or until it flows over the top. Underdraining supplies the necessary outlet for this excess moisture at a proper depth from the surface; it "lowers the water line."

With plastic clays the process is slightly different. Clay will absorb nearly one-half its bulk and weight of water. In drying, it shrinks and is torn apart in different directions. The fissures thus commenced by a tile drain become new drains to lead water to the tile; and so the process of contracting and cracking continues until a net work of fissures is produced, and the stiffest clay is thereby drained.

The injury done to roads by frost is caused entirely by the presence of water. Water expands on freezing, and the more there is under a road, and above frost line, the greater is the injury. In freezing, the particles of soil in immediate contact with the water are first compacted. When room for expansion ceases within the body of the soil itself, owing to its saturated condition, the surface is upheaved. When thawing takes place the sub-soil will be found honey-combed, ready to settle and sink beneath traffic. It is therefore of the utmost importance that the soil should be relieved of all water of saturation as quickly as possible by underdrainage. The impassible condition of most roads in Ontario during the spring, often axle deep with mud, is to be attributed very largely to a wet sub-soil which has been honey-combed by frost.

The extent to which underdrainage should be used, must be controlled by the quality of the soil over which the road is laid. There are instances on sandy, gravelly and porous soils, in which underdrainage is so perfectly provided by nature that artificial

drains are not needed. Clays nearly always are benefited to such an extent as to render the outlay for sub-drainage a most profitable investment. The necessity of drainage is further controlled by the situation of the road. If the ground is high-lying it will be less in need of drainage; but if low-lying, or if it receives the soakage water from up-lying lands, it will usually be impossible to secure a dry sub-soil without the use of tile.

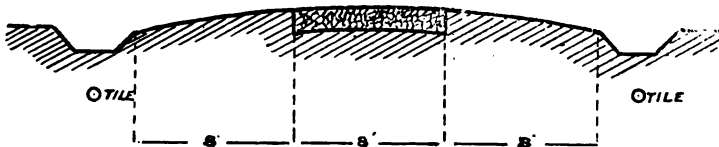
The drain should be placed below frost, otherwise water freezing in the tile will burst and destroy them. If not below frost line the drain will be apt to be stopped up during the spring, the period during which it is most needed. The fall should average one foot in 100; the minimum should never be less than one in 1,000. The tile should be evenly laid; the capacity of the entire drain is regulated by the smallest portion, and to lay tile in an undulating line is equivalent to reducing the bore; when unevenly laid it has a further tendency to catch sand and solid matter, producing stoppages.

There is some dissension among road-makers as to where underdrains should be placed with respect to the roadway. Some prefer one tile drain under the centre of the road, this with the mistaken idea that the water will be caught as it percolates through the road bed. A road bed, if nicely crowned and well compacted under the roller, will shed the surface water to the side gutters without permitting it to pass, to any extent, into the road foundation. It is better practice to place two tile drains, one under each of the surface gutters or ditches where they may if necessary, serve as outlets, catch-basins being provided to permit surface water to enter the tile when natural outlets cannot easily be obtained.

The advantages of the two tile drains, one under each side of the roadway, compared with the plan of having one drain in the centre, are several: The two drains are more effective in securing perfect drainage than one could be; the aftermath of settlements in the centre of the road is avoided; the tile drains on an old road can usually be laid at a greater depth if placed under the old open drains; the expense of placing one drain in the centre of an old road is often greater than that created by placing two drains at the sides; when at the sides they may be more easily used when needed, as outlets for surface drains. The rule, however, of placing tile drains on each side of the roadway need not be rigidly followed, but should be judiciously applied, according to the amount of underdrainage needed, the nature of the soil, the location and the opportunity for obtaining outlets.

DIMENSIONS OF COUNTRY ROADS.

The width of the graded portion on the majority of country roads has already been fixed. Various ideas have prevailed among the different pathmasters regarding this detail, and the width differs accordingly, ranging from ten to forty feet. In the case of old roads which have been coated with gravel or crushed stone, it will seldom be deemed practicable to change the existing width. Twenty-four feet between ditches will generally be found ample, while less than eighteen feet is seldom advisable.



CROSS SECTION OF COUNTRY ROAD.

Common field tile underneath open ditches. Gravel or broken-stone roadbed, eight feet wide.

It is not to be understood that the width of the graded roadbed is necessarily the width of the metalled portion. The latter, for the majority of country roads, need not exceed eight feet, but for very largely travelled highways, may increase to twelve or even sixteen feet.

The depth of gravel or stone to be used must vary with the quality of the material, the amount and nature of traffic on the road, and the nature of the sub soil. It is obvious that a dry, compact and stony sub-soil will need less metal than would a plastic clay, difficult of drainage. No definite rule can therefore be laid down other than that from six to twelve inches of well consolidated material will afford a sufficient range to accommodate most circumstances. Under proper conditions, ten inches of metal should accommodate the heaviest traffic to which a gravel or broken stone roadway can be economically subjected.

From the edge of the open drain the graded portion of the roadway should be crowned with a circular rise of one inch to the foot from side to centre. That is, a driveway twenty-four feet wide should be one foot higher at the centre than at the side. This amount of crown compared with European practice may appear excessive, but with gravel roads, and roads metalled with the quality of stone commonly available, this crown is no more than sufficient to provide for the wear and settlement, consistent with good surface drainage.

The elevation of the road above the level of the adjacent land, need not be greater than is sufficient to provide against the overflow of storm water, which should always be guarded against. The depth of the open drain must vary according to the amount of fall and the quantity of water to be provided for ; also according to the sub-drainage needed and provided. When tile sub-drains are used, the open drain can usually be very shallow ; in which case the width of the graded roadway can be narrowed, there being no danger of accidents such as are caused by a deep trench at the roadside. The tile drains, as elsewhere stated, should be placed below severe frost, usually a depth of three or four feet.

CROWNING.

A very notable defect of most country roads is the flat or even concave surface ; others present the opposite extreme, and are so rounded up as to be dangerously high in the centre, making it difficult for vehicles to turn out in passing. Roads must be crowned sufficiently to shed the water from the centre to the open drains at the side, otherwise water will stand in the roadway, soak into it, soften and cause rapid wear and decay ; but a crown higher than is necessary to properly drain the surface is also objectionable.

The amount of crown must be sufficient in the newly constructed road to provide for wear and settlement. It should be greater in the softer and rougher varieties of pavement than in those which are hard and smooth ; a gravel road, or a broken stone road, must have a greater crown than a brick pavement. The amount of crown needed on a gravel road or one of broken stone varies with each of these classes according to the quality of gravel or stone, the nature of the subsoil and the care taken by rolling to provide against settlement. The amount of crown for newly built gravel roads has been stated under "Dimensions of Country Roads," as one inch of rise to the foot of width from the edge of the ditch to the centre of the road, and this should be increased in the construction roads on hills according to the steepness of the grade.

The amount of crown should not be more than sufficient to provide for surface drainage. A steeper crown than is necessary tends to confine traffic to the centre of the road, and in turning out, the weight of the load is thrown on one pair of wheels in such a way as to rut the side of the road. The shape of the crown is a matter on which expert road-makers differ, but with the class of material available for roads in Ontario, and the methods and plans of construction, a form as nearly circular as possible will be found most serviceable, and most easily obtained.

HILLS.

Roads located on hills, or along the sides of hills, are generally found difficult to build and maintain, and very often we find a very large proportion of statute labor annually placed on them, to little effect. The difficulty usually arises from the rushes of storm water, from springs underneath the road, and, especially on sidehill roads, from water soaking from higher levels.

The rushes of storm water are often occasioned by the practice of carrying water long distances in open drains, and finally pouring it over the hill by the roadside. If the hill is steep, and a cut has been made, the water is not, and very often at the time of spring floods and freshets, cannot be kept in the open drains, and so is allowed to make a channel of its own down the centre of the road. This condition is the common result of not disposing of water in small quantities along natural watercourses. No water should, as a rule, be allowed to pass over the hills by the roadside, except that which naturally falls on the surface of the slope. Provision should be made for the disposal of water in the drains back of the hill, by carrying it through private property, under the authority of the Drainage Act, if necessary. Property owners, however, should understand the wisdom of permitting drains to be constructed across their lands, when the benefit to be derived is not only better roads but better drainage of their own fields.

The surface drainage on hills should be very pronounced. The crown of the road should be slightly higher than is needed on level ground, a rise of one and one-half inches to the foot from side to centre being advisable for gravel roads. The crown must be sufficient to draw the water to the side gutters, and to do so, it must be sufficient to overcome the tendency of the water to flow directly down the hill, following the line of the wheel tracks. If the water commences to take the latter course, the wheel tracks are quickly deepened to ruts, stones are loosened or protrude, and the road becomes roughened and channeled.

Under-ground currents of water often find outlets on the hillsides. If any of these springy places occur under the roadbed, it will be necessary to tap them at a good depth below the surface with tile drains. In such cases, tile drains will be needed under the open drains at the sides of the road, and the blind drains may then be carried diagonally across the road into the side underdrains. The open drains will sometimes need to be protected with cobble stones, if the hill is long or subject to damaging rushes of water.

Roads passing along the sides of hills are frequently softened and injured by the soakage water from high lying lands. This water should be intercepted before it passes under the road, by a deep drain along the side of the roadway next the hill. Tile should be used, if possible, instead of a deep open drain, and the trench filled with gravel, stone or other porous material, to more readily intercept and absorb the soakage water.

Municipalities will usually find it a measure of economy to bring hill roads to the grade at which they are desired to remain as quickly as possible, and to this end special money grants will be necessary. To leave such work to be performed by statute labor alone is not often satisfactory. The grading done one year is apt to be so inefficient that it is, in a large measure, destroyed by the rushes of water in the ensuing wet seasons. The roadway, moreover, being annually covered or cut for a number of years, is slow to settle, becomes impassable on the slightest provocation, and absorbs labor which is needed by other sections. Municipal grants are needed on main roads, but they are also needed in doing permanent work on the lesser travelled roads, where hills or other unusual circumstances of location render the construction of roads a matter of more than average difficulty. The labor and cost of road building should be equalized as far as practicable among the different sections of the municipality, so that efforts put forth in road improvement will not be retarded by discouraging difficulties.

EMBANKMENTS AND CUTTINGS.

The protection of the sides of cuttings and embankments should be skilfully attended to. It is very common to see these washed away in places after a heavy rain, or after the spring thaw; the sides of the cuttings settle into and fill the open drains, and the water is forced into the road; the sides of embankments wash away leaving dangerous holes in the road. The tendency is to make cuttings and embankments too steep, with a desire to do the least possible amount of work.

The stability of earth slopes is endangered by the action of air and moisture, especially by alternate frost and thaw, and depends on the ease with which water is drained away. A certain amount of moisture increases the strength of the slopes, but too much acts like a lubricant, and reduces the earth to a semi-fluid condition. Clay retains water and becomes pasty. Sand, if in a basin of water-holding earth, becomes a quicksand and is completely unstable. A mixture of sand and clay, the former favoring the access of water, and the latter preventing its escape, is one of the most difficult cases to deal with. There is a certain "angle of repose" at which the tendency of earth to slip is overcome. This angle varies with different kinds of earth, under various conditions of moisture. Wet clay is troublesome, and an angle of about 16 degrees is sometimes needed to secure it. Well drained clay, however, will rest at an angle of 45 degrees, or a slope of one to one. With average gravel and compact earth, a slope of one to one is a safe angle, although first-class gravel will retain an almost vertical face for a considerable time. Sand varies greatly, "water sand" being no better than wet clay. Dry sand usually needs a slope of one and one-half to one. Vegetable earth, also, is apt to be unstable and needs a slope of one and one-half to one. Rules of this description cannot be laid down with sufficient accuracy to be of use, except as they serve to indicate what is to be expected with different soils. The qualities of soils are so variable that it is necessary to learn by observation what slope is needed for a particular piece of earthwork.

The natural form of an earth slope when in permanent repose is a concave curve, with the flattest portion near the bottom. There is a careless tendency to leave the slope rather in the opposite form, with an outward curve. Convex or straight slopes will invariably slip until the natural form is obtained, and in cuttings or embankments approaching ten feet in height, care given to a proper construction in this regard is always profitable.

A dry stone wall at the foot of an embankment or cutting will protect the drain from slipping earth. A coating of sod is one of the best protectors to the slope; and a few inches of vegetable mould over the surface, with a liberal sowing of grass seed, is a measure sometimes adopted.

LOCATION OF ROADS.

A very great number of the roads in this province are faultily located. This has resulted not only in waste and inconvenience in transporting loads, but has very materially increased the difficulty and expense of building and maintaining the roads. The basis of land surveys must be rectilinear; concessions and lots should in the survey be marked off by straight lines. The difficulty has arisen from blindly following these lines in the construction of roads, irrespective of their suitability for the location of a road. While land has been subdivided by straight lines, it was never the intention that these lines should mark unalterably the route of roads.

There is an advantage to the farmer in having all his fields of rectangular shape, as they can be cultivated more easily than when outlined by circular or irregular lines. There is a disadvantage, too, in having an estate cut into separate sections by diverted highways. These are obstacles to the proper alignment of roads in long settled and populous districts, but present little difficulty in new portions of the province. How-

ever, it is usually very much more to the interest of a property owner that the roads leading to his farm should be good and easily maintained than that his farm should be in a compact block with the roads to it impassable during a portion of the year, and even then expensive to build.

It is, of course, desirable that a road between two points should be as direct and short as possible. But a road is not necessarily more direct because it follows absolutely one pointing of the compass. The line followed by a vehicle, leading up the hills and down into the valleys, may be no shorter, nor perhaps as short, as a diverging route following comparatively level ground. Not only may nothing be gained in point of directness by following the line of the original survey, but there is to be considered the greater horse power required to move loads up and down the hills, demanding, too, a greater expenditure of time.

The expense of building a highway is materially increased by steep grades. A moderate divergence of numerous highways in the province would do away with many expensive and unsatisfactory cuts and fills, and with a large number of bridges. The unsuitability of the soil also, if low lying, swampy, or composed of vegetable matter, may render advisable a change of location in favor of a course which will offer a firmer and more easily drained subsoil.

Directness must frequently be sacrificed to obtain an easy grade, and to avoid expensive construction over bad ground, cuttings, fills, bridges and excessive grades. Councils are authorized to alter the location of roads by the Municipal Act, in a manner fair to all parties, and it is advisable that this power be judiciously used whenever circumstances render it practicable. Opposition will no doubt be offered in some cases by the individual property owners affected, but councils representing the general public have a responsibility resting upon them which should not be shirked in a matter so important.

REPAIR AND MAINTENANCE.

Roads should be repaired, not once a year, nor twice, but as soon as signs of wear appear. The statute labor system as usually operated, with one annual overhauling, is the most wasteful plan that could be adopted. Ruts should not be allowed to form in a gravel or stone road when once properly constructed, but material should be kept in place by a constant use of the rake. Settlements and hollows should not be allowed to hold water and create a pitchhole for want of a load of metal. Drains should not be allowed to become obstructed, thereby saturating and softening the whole roadbed, because it is nobody's business to spend a few hours in freeing the water. Culverts should not stand full of water to be burst by the expanding ice because of a neglected outlet. An almost inexhaustible list of these everyday occurrences could be mentioned, which in themselves apparently trifling, become in the aggregate of very great importance. Road-making is made up of details none of which can be overlooked, except at a loss.

The pathmaster should have power to give immediate attention to all emergency work rendered necessary by washouts, etc., either by personal or hired labor. Under the advice of the supervisor, he should be able to send a man over the beat as often as necessary to repair the effect of ordinary wear. Better still, a man should be employed to devote his whole time to a certain mileage of roads, which would include a number of beats, to make repairs as they become necessary. Every farmer, too, should appreciate the value of good roads sufficiently to voluntarily devote time to the roads passing his property, rather than permit them to become bad or impassable because of neglect.

If a general municipal system of employing a man to take care of certain beats is not practicable, a plan followed in at least one township may be of service; in which the residents interested in certain of the main roads have subscribed an amount sufficient in all to keep a man constantly engaged on each road. As a measure of economy, it is certainly advisable to adopt some means to prevent the roads getting out of repair.

ROAD MACHINERY.

Improved and modern road-making machinery is as necessary in the construction and maintenance of highways as are self-binders in the harvest field. Roads cannot be well or economically constructed without suitable tools and implements. If a workman is known by the condition of his tools, a very damaging reflection is certainly cast upon the majority of townships. Not merely are improved machines seldom employed, but the scrapers, plows, wagons, etc., used in the performance of statute labor are rarely on hand as needed, and the utmost carelessness is observed with regard to them.

GRADERS.

Road-grading machines are now very commonly used by townships. Their greatest value is in the shaping of dirt roads. The crowning of the roadway can be done very rapidly by their use, and for this work alone every township requires at least one grader. Some townships using as many as four, feel that they are needed. On gravel roads there is a marked tendency for ruts to form in such a way that the metal is forced upward and out from the wheel tracks, and a road grader can very profitably be used to level the ruts by scraping this gravel back to its place. Another important quality in the maintenance of gravel roads, is the facility with which the shoulders of the roadway can be cut off. These shoulders usually consist of square corners left in the original construction of the road, augmented by dusty material washed down from the centre. They obstruct the flow of water from the gravelled portion to the open drain. When cut off by the grader, the material should be thrown outward and across the ditch and used in levelling the sides of the road.

The stuff from the shoulders and from the ditches should never be drawn to the centre of the road, a practice which has ruined a number of excellent gravel roads. It is a mixture of dust, clay, horse droppings and sod. Placed on a good gravel foundation, it may afford a temporary benefit in summer, but in wet weather it works the destruction of the entire road. The shoulders having been formed, the proper treatment, as stated in the section on "Existing Roads," is to crown the roadway with clean gravel.

ROCK CRUSHERS.

The rock crusher is one of the most important of modern additions to the list of road-making machines. By their use stone can be crushed so much more cheaply than by the old method of hand breaking, that, so far as cost is concerned, stone roads are within the reach of every municipality having suitable rock in the vicinity. In the treatment of gravel a crusher is frequently most valuable, since, if containing many large stones and boulders, it will be possible to place a crusher in the pit and pass all the gravel through. A rotary screen attached to the crusher and driven by the same power will screen the resulting metal, removing sand and clay. Whenever a crusher is employed the rotary screen should be used also to separate the road metal into grades according to size.

The most common type of rock crusher is that in which the breaking is done by the opening and shutting of strong iron jaws arranged so that they can take in large stones, and, by successive openings and shuttings, fracture the stones until the fragments are sufficiently small to drop between the lower margins of the jaws. The fragments are there caught in a chain of pockets, or elevator, and passed up to the rotary screen, which is so designed as to separate the product into grades according to size.

Rock crushers can be readily moved from place to place, and where boulders are plentiful in the fields along the road, may be set up so as to crush stone for short sections of road as required. Municipalities in which boulders are plentiful, will find the property owners willing to provide, at the crusher, all the stone that can be gathered from the fields.

ROLLERS.

Road rollers, the benefit of which are referred to elsewhere, are of designs to be operated by horse or steam. Horse rollers usually consist of one main roll in two sections. The standard diameter is fifty inches, with each section twenty-six inches wide, giving a total rolling width of fifty-two inches. The standard weight is about four tons, but may be increased by loading to six or eight tons. The reversible type, whereby the tongue may be revolved from one side to the other is to be preferred.

Steam rollers generally weigh from ten to twenty tons, the most popular being of ten, twelve or fifteen tons. For country roads a weight of ten tons will be sufficient, especially on gravel roads, and in view of the strain on culverts and bridges. In towns twelve tons, with the ability to load more heavily for surface consolidation, will be satisfactory. If it is proposed to rent it for township work, ten tons will generally be better, and will give excellent results. The lesser weight, while requiring more repeated operation to compact the road metal, is believed by some to do more durable work. Steam rollers, of which illustrations are given, are all very much of the same type.

SELECTION OF MACHINERY.

In all kinds of machinery, the most important points to observe are simplicity of design, quality of material and workmanship, ease of operation, lightness of draft, and adaptability to the work for which it is intended.

OPERATOR.

Graders, crushers and rollers should not be passed around from section to section for everyone and anyone to operate, but capable men should be employed for this purpose and should always accompany them. It is further necessary to see that the operator is a man who knows something of road-making and of machinery, and has good practical judgment. A machine of itself possesses very few of these qualities, and unless the operator does, dissatisfaction and failure will result.

PURCHASE OF MACHINERY.

With regard to the purchase of these machines, it is desirable that every township should possess at least one grading machine, and as many more as circumstances may require. The extent to which broken stone will be needed and the location of the quarry, will suggest the best policy to pursue with respect to the crusher. When one crusher to provide stone for the main roads of a county is sufficient, it may be advisable for the county council to own it, arrangements being made with the various towns and township municipalities, either for the rental of the machine or for the purchase of the crushed metal. Circumstances may render it advisable for a private citizen to provide metal at a fixed price per cord; thus a man owning a threshing machine, and having the steam engine idle for a portion of the year, might be readily induced to consider such a proposition, to the advantage of all parties concerned. If water power is available within reach of a quarry, it will afford a cheap means of obtaining the requisite power.

BRIDGES AND CULVERTS.

Experience has shown durable improvements to be the most economical. One of the most common leakages of municipal funds arises from the maintenance of temporary wooden bridges and culverts. The life of a wooden structure is, at the outside, not more than one-half or one-third that of an iron or stone bridge, or culvert of cement or masonry, while the cost of keeping the former in repair during that period, is very considerable. The price of the timber is constantly rising, and, in many localities, first class material is difficult to obtain at any reasonable price. The cost of iron has been very much reduced of recent years and will probably become still less.

Good judgment is required in estimating the right size of waterway for a particular location. Elaborate rules might be given for determining the probable flow of water from a given area, but these would be of little assistance to the councillor. In this respect, consideration has not only to be given to the amount of the area drained, but also to the amount, slope and general shape of the lands drained, so as to know whether the water will reach the culvert or bridge rapidly and in a large body, or gradually with little force. The waterway must be capable of accommodating not merely the ordinary flow, but the unusual floods. Water checked and permitted to back up is a frequent source of wash-outs, and in the case of culverts permits the water to soak into and soften the roadway. On the other hand a waterway larger than is necessary is needlessly expensive, so that careful consideration as to the size of the culvert or width of span is a matter which must be urged. Error should be on the side of an excessive, rather than insufficient capacity.

When the country was covered with forest, the water was impeded in its flow over the surface of the ground by fallen timber, and rough and broken land; and after reaching the stream, violent rushes were prevented by standing timber, accumulations of floating logs, and other debris. These obstructions were taken away with the removal of the forests and the cultivation of the soil. Drains have been made, and furrows created by the plow, to lead the water quickly to the streams. More recently we find the ravines being stripped of their timber, thus giving an uninterrupted course to the waters swollen by the storms of autumn, and the melted snow and ice, and heavy showers of spring. In the construction of bridges and culverts these considerations must not be overlooked, and for this reason those in charge of township roads should make a systematic study of the volume and behavior of streams passing through every opening. When building or rebuilding any of these structures, ample provision should be made for the free passage of water.

The present practice is generally in opposition to this principle, the tendency being to construct a narrow channel in order to lessen the span of the bridge or culvert. A disposition to use iron, stone or concrete on account of its permanency is exhibited, but with this there is a tendency to construct the channel so as to bring the cost within the limits of a certain amount appropriated for the purpose. From this cause numerous costly structures have been and are being gradually washed away at the times of great water fall.

Permanency in these structures does not consist in the use of durable material only, but also in so designing them as to provide sufficient capacity and power of resistance to any strains likely to arise.

These requirements cannot be measured by the ordinary or the average flows but by the heaviest rushes of water. Economy in this matter does not mean the saving of a few dollars in first cost at the risk of efficiency, but in the expenditure of a sufficient amount to provide for every emergency, thus securing the investment.

BRIDGES.

It is the custom in erecting iron bridges to advertise for tenders, and too frequently a committee or council completes the purchase without any advice on the matter, the lowest tender being accepted, irrespective of the quality of material, workmanship or design of the bridge. There is as much variation in the quality of iron bridges as in the quality of timber bridges.

No one pretends to be a capable judge of timber without considerable practical experience, and with iron there is an equal or greater occasion for being able to detect any weakness. Weighs iron should meet the standard of the coil bend test, by which it may be bent, without fracture, until the ends are no farther apart than the thickness of the iron. Iron bars should not have a less ultimate strength than 55,000 pounds per square inch, nor an elastic limit less than 25,000 pounds.

The sustaining strength of a bridge is dependent upon the weakest portion, just as the strength of a chain is dependent upon the weakest link, and for this reason the matter

of making joints is of very great importance. The tendency is to permit all joints to be riveted, a cheaper method than making "pin" and "screw" joints, but not so strong and durable.

The design of an ordinary highway bridge is chiefly a matter of economy in material, so long as one of the standard forms of beam truss, suspension truss, or bow string is used. No design should be adopted in which the amount and character of every strain cannot be fully determined. But in all these matters respecting the merit of iron, joints, design, it cannot be expected that the average councillor will be able to form, with certainty, a correct conclusion. It is unreasonable to expect it, and the council which undertakes to purchase an iron bridge of any considerable dimensions without the assistance of an expert in iron bridge construction is unreasonable in so doing. To erect a structure which is not positively known to guarantee every probability of safety at the time when the greatest strain is upon it, risking property and endangering life, is little short of crime.

In choosing an iron bridge, it is as well to permit the bridge companies to prepare their own plans and specifications; but these with the stress sheets, should be submitted to an expert builder of iron bridges, and the council should then be guided by his decision. If his services cannot be employed throughout the construction, he should at least be called upon after the erection of the bridge to see that the work has been completed according to the specifications. There are, doubtless, honest bridge companies, but, in competition, when the lowest tender is likely to be accepted, experience has proven the tendency to lower the cost by using low grade material and workmanship.

Stone bridges are the most handsome and durable that can be built. The life of such structures is limited only by the quality of the material and workmanship. Bridges of stone arches built in the time of the Roman Empire are still in existence. Owing to the greater cost, however, they are very rarely met with in Ontario, except in localities where stone is plentiful. With stone that resists decay, with the best quality of cement, with well designed and carefully formed arches and piers, bridges of masonry leave little to be desired in regard to durability. Such arches are monumental, will resist with little repair the wear of centuries, and certainly no form of bridge architecture will accord better with the landscape.

CULVERTS.

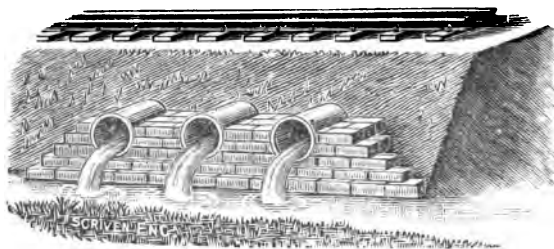
As with bridges, a large portion of the funds of a municipality is wasted on poorly constructed wooden culverts. Wood is only of temporary duration and usually renders poor service while it lasts. For the smaller sizes, cement, earthenware (sewer), iron and box stone culverts should be used. For larger culverts, arches of stone or brick are to be preferred.

Pipe can be safely used up to a diameter of twelve inches. The capacity of the culvert may be increased by laying two parallel lines of pipe. In laying the pipe, the bottom of the trench should be rounded out so that the lower half of the pipe will fit securely, with proper depressions for the "collars" or sockets, and the earth should then be rammed around the pipe solidly, but carefully so as not to fracture it. Pipes are not affected by the expansion of the earth around them, but care must be taken to provide a good fall for water, with provision for taking the water freely from the lower end. Water standing and freezing in the pipe is liable to burst it.

A culvert should be able to discharge water under head without damage to itself, and for this reason it is generally advisable to caulk or close the joints to prevent water from forcing a passage through the joints and along the outside of the pipe. For a similar reason, and to protect the pipe from injury by accidental blows, it is advisable to place a bulk head of brick or stone at each end. The foundation of this parapet wall should be placed below the action of frost. In constructing the bulk-head at the outlet, it should be set so as to provide a rapid fall to avoid the danger of settlement.

For culverts requiring a greater capacity than that offered by three lines of twelve inch pipe, stone masonry should be used throughout. Where large flake stone is plentiful, a very cheap culvert for all small sizes can be built by laying two side walls and covering with flagstone.

For culverts of from five to fifteen feet span, brick or stone masonry should always be employed. The form of the arch is a matter of very great importance. Semicircles, or full centre arches are simple and strong, but in large spans a correspondingly great rise is necessary, which may require an objectionable height. To avoid this, compound curves



may be used, but should always be designed by an engineer for each particular case, and skillfully erected, as certain mathematical principles have to be observed. The number of centres must be uneven, the tangent at the crown must be horizontal and the tangents of the curves at the springing must be vertical.

Cement concrete is being used to some extent in the construction of culverts, and with first-class cement, workmanship and design, will produce excellent results. It is important to place the foundation layers of concrete on a firm and unyielding strata of earth, well below frost and safe from the action of running water. All walls should have a batter on the side next the embankment as a protection against the thrust of freezing earth. Orib work should be firmly braced so that the cement may be thoroughly rammed. Coarse gravel, from which clay and earthy matter has been removed, may be used in forming the concrete, but clean broken stone is much better. The sand should be clean and sharp. The cement should be of some favorably known brand, delivered in barrels or other equally safe receptacles, and should be stored in a tight building, or otherwise properly protected from the atmosphere. Cement which, when opened, indicates by a granular appearance that it has been acted upon and set by the admission of moisture should be rejected.

On roads over which one hundred vehicles pass daily, one may, in almost any township, see the drivers compelled to check their horses to a respectful walk, and then bump over the corners of a box drain or culvert standing above the road. The time and energy wasted, the injury to vehicles and annoyance caused in this way would build, a score of times, good and durable culverts which would not interfere with travel. The wastefulness is plain, the remedy simple, and as such, illustrates the little thought which has been given to the care of highways.

WAGON TIRES.

Vehicles designed for carrying loads of a ton or more should have tires at least four or, better, five inches wide. With expensively built stone roads the effect of narrow tires may be so repaired as to keep the road in a fairly good condition though at very great cost. But broad tires are particularly necessary on roads such as are constructed in this country. Narrow wagon tires are the greatest destroyers of gravel and broken stone

roads built and maintained as they are in Ontario. Even with traffic which is not excessive, our country roads will not be kept in a moderately good condition so long as they are subjected to the strain placed upon them by narrow tired wagons.

There are two aspects of the question of tire widths to be considered.

- (1) The relation of the tire to the amount of horsepower needed to move the load.
- (2) The effect of different widths of tires on the roads.

With respect to the first of these, the tractive force required, the effect of the width of tires varies with the condition of the road. On a smooth, hard, unyielding pavement there is practically no difference. With soft roads, deep with semi-liquid mud, the advantage is slightly in favor of the narrow tire, since the wide felloe has a tendency to carry the mud with it. It is with the intermediate stage, such as exists on a good gravel or dirt country road, that the benefit arises. Through such surfaces the narrow tires cut and the load is, in effect, being constantly drawn up hill, but the broad tires roll smoothly along the top. A wagon having tires wide enough to keep the wheels from cutting into the road will plainly draw more easily than one which plows through the mud instead of running over it. Experiments have shown that the loads which on narrow tires sink to the axles can be drawn without difficulty when broad tires are used. The broader base takes the firmer hold of the road, and the wheel revolves more easily and perfectly. It is admittedly the case that wide tires are an advantage on farms, but there appears to be a persistent effort put forth to prevent their use on the roads.

It is urged against wide tires that they do not roll freely in the ruts made by narrow tires. So long as narrow tires are commonly used this will be the case to some extent; but on the other hand, if wide tires were generally used the ruts would not exist. In any case, with narrow tires the bottom of the ruts made by the narrow tires are uneven, and the narrow rims are constantly grinding against the sides of the ruts, creating the greatest friction, so that the objectionable difference is not so great as appears on first sight, if it exists at all.

It is further contended that the wide tires come in contact with more loose stones than do those with a narrow tread. The greater resistance offered in this way is more than counter-balanced, however, by the loose stones dropping into the narrow ruts. In the one case the wheel goes to the stone, in the other the stone gets in front of the wheel. The irregular bottom of the ruts, and the stones in the narrow ruts keep up a constant vibration of the wagon, which transmits a swinging motion to the tongue, galling and annoying the horses and destructive to conveyances.

Broad tires actually improve a road by rolling it down hard, and leaving it smooth so that water runs off without doing injury. Narrow tires cut and grind, burst and plow their way into the road, leaving ruts and holes to catch and hold water. The difference between the two is on a par with the difference between a pick and a pounder. The one tears up, the other consolidates.

The narrow tire is a rut producer. With a load of say 2,000 pounds, each wheel must support 500 pounds. Then a narrow, straight line, the width of the tire, must support 500 pounds. With macadam, gravel and dirt roads the narrow tires commonly used must have a greater bearing, and so, the width of the tire being fixed, the wheel sinks into the road so as to extend the bearing along its circumference. In this manner the rut is commenced. Other narrow wheels follow, deepening the rut and loosening the earth around it. After a rain water lies in the hollow to assist the work of destruction.

Broad tires on the contrary are a benefit rather than a detriment to the road. They do very largely the work of a roller. Instead of a bearing of one and a-half or two inches, the width of a narrow tire, this is increased to four, five or more inches. The advantage is at once apparent. The broad tires do not sink at all so deeply into the road as do the narrow, but distribute their weight across the road as well as lengthways. Their broad bases do not slip from protuberances so readily, and the consequent jolting is avoided.

They do not push loose stones before them, tearing up the road, as do narrow tires, but pass over them, pressing them into the road. Grinding, upheaving and fracturing do not take place as with narrow tires, the road is compacted and compressed, and rendered thereby less pervious to moisture. This means that at all times the road is better, while the cost of maintenance is very greatly reduced. Were the benefit of broad tires better understood in Ontario, our unimproved roads would be very much less cut up, and improved roads would be more cheaply kept in repair.

In descending hills with heavy loads, it is a frequent practice with teamsters to lock one or more wheels. It is evident that the injury resulting to the road, which is very great in any case, is much increased when the load is supported by cutting tires. Hills, even under ordinary traffic, are expensive to maintain, and the width of the tire used with locked wheels becomes a very important consideration. In nearly every part of the province, this is the case to some extent. But there are districts where hills, many of them steep, are of constant occurrence. In such localities the practice of locking wheels is very common, and the necessity for wide tires is of the utmost consequence.

While a width of four or five inches is very satisfactory on farm wagons, the drays and tonnage wagons used for the transportation of excessively heavy freight in towns could reasonably be twice this. England, and all the progressive European countries, have laws regulating the width of tires according to the load vehicles are designed to draw. Sometimes the width is regulated by the size of the axle. In France, a country which presents some of our most perfect models in road-making, tires on market wagons range from three to ten inches, the majority being from four to six. The gauge of the wheels is sometimes set so that the track of the front wheels comes inside the track of the rear wheels. In New York State the turnpike law grants reduced rates of toll to vehicles with broad tires. The Michigan road law provides that users of wide tires are entitled to a rebate of half their road tax.

That wide tires are not more generally used in this country is to some extent the result of prejudice. People are not accustomed to seeing them, and wide tires, therefore, appear strange and awkward. When wide tires are generally used, as they certainly will be, the reverse will be the case, and narrow tires will be looked upon as the oddity, and a very objectionable one. As a means towards overcoming this practice, town and city municipalities could well afford to provide their watering carts, garbage wagons and other vehicles used in corporation work with wide tires.

City and rural municipalities cannot too soon set laws in motion in this regard. Obviously the use of wide tires cannot be made immediately compulsory, without working injustice. Provision could be made, however, that a by-law regulating the matter would come into force after a term of years; fair warning would thereby be given, and little inconvenience would be felt. Before the time for enforcing the by-law had arrived, the use of wide tires would, in anticipation, have gradually become more common. The beneficial effect of wider tires would then be apparent to all, and public opinion would demand and sustain the enactment. The people are competent to judge in this matter, as in others affecting personal and public interests. The great reason that wide tires are not now used is that the public has not had an opportunity to judge of their merits in a practical manner. Further, the users of the road have in the past looked at the matter of draught only. They prefer wide tires on the farms because the fields and lanes are not cut up by them. The roads, however, have been regarded as public property, and the users have not felt a personal interest in their condition.

INSTRUCTION FOR PATHMASTERS.

The council and road supervisor should use every means to interest pathmasters in the subject of road improvement, and to keep them interested. An association of township, or even county pathmasters, should be formed to meet annually for discussion and for the interchange of ideas, and it should be one of the duties of every pathmaster to attend this convention. The council should see that the pathmasters are provided with

printed matter, containing good practical hints on the principles of road-making, and the best means of carrying them into effect. A number of the directions most important to follow may, as a simple measure, accompany each year's road list. The following is a model set of rules, which could be impressed on the pathmaster by this means :

- (1) Carefully plan and lay out the work before calling out the men.
- (2) When preparing plans, keep the work of succeeding years in view.
- (3) Call out for each day only such a number of men and teams as can be properly directed.
- (4) In laying out the work, estimate on a full day's work from every man, and see that it is performed.
- (5) See that all the gravel hauled is clean.
- (6) Every wagon box should hold a quarter of a cord of gravel.
- (7) Specify the number of loads to constitute a day's work.
- (8) Properly grade and crown the road before putting on gravel.
- (9) A fair crown for gravel roads is one inch of rise to each foot of width from the side to the centre.
- (10) Give the roadway on hills a higher crown than on level ground, otherwise water will follow the wheel tracks. One and one-half inches to the foot from side to centre will be sufficient.
- (11) Spread the gravel evenly over the road, and keep it raked or scraped into the wheel and horse tracks until consolidated. A road roller should be used for compacting the gravel.
- (12) On all gravel roads, crown the roadway by cutting off the sides, putting new material in the centre. Do not cover the old gravel foundation with earth from the side.
- (13) Make the width of the road as uniform and the grade as easy as possible.
- (14) Remember that good drainage is absolutely necessary.
- (15) Whenever water stands on the roadway, or by the side of the road, or whenever the ground is seen to remain moist, better drainage is needed.
- (16) See that drains are free from obstruction, that they have a good fall and proper outlets.
- (17) Surface water should be disposed of in small quantities. Great accumulations are hard to handle and are destructive. Obtain outlets into natural water courses as often as possible.
- (18) Instead of having deep ditches to underdrain the road, use tile.
- (19) Give culverts a good fall and free outlet, so that water will not freeze in them.
- (20) Make early arrangements for having on the ground when required, and in good repair, all machinery and implements to be used in the performance of statute labor.

SNOW OBSTRUCTIONS.

To prevent the roads becoming obstructed by snowdrifts during the winter months has become an important question in nearly every portion of the province.

Snowdrifts are caused by the obstruction of the currents of air, those close to the ground, which are carrying the drifting snow. Where the forest covers the ground, the winds have not sufficient strength to carry the snow, so that it lies evenly, and with a uniform depth. Wherever the land has been cleared, currents prevail, and the velocity of these currents depends upon the extent of the clearing. The completeness with which the country is being stripped of trees is largely responsible for the blocked condition of our roads in winter.

Fences along roadways should be either entirely open or very close. The intermediate stage, found in the rail fence, offers an obstruction to the wind but permits the drifting snow to pass through, subside, and pile up on the sheltered side of the fence. This is one of the most common causes of blockades. High, close, board fences have been built by railway companies at certain points to prevent drifting, and have proven very effective, but the cost is prohibitive for ordinary highways. The drifting snow is close to the ground, and such fences obstruct the velocity and change the current of the wind, causing the snow to fall beside the fence, before passing over or through it into the roadway.

Open wire fences along the roads have been encouraged by many municipalities, the council generally providing the wire. Wire fences prevent the snow from accumulating so as to form banks and pitch holes, and is a decided improvement, but by no means a complete preventative. The uninterrupted current of the wind constantly moves the loose snow into and fills up the beaten sleigh path, making traffic heavy and gradually raising the centre of the road to such a height as to render turning out into the loose snow dangerous, especially with loaded teams.

A necessary adjunct to open wire fences along the highways is tree planting to break the current of wind, and to prevent the sweep across wide clearings in which it gathers a large amount of snow. By this I do not mean planting trees along the roadway only, but along the division fences on the farms to interrupt the velocity of the wind before it reaches the roadway. Observation will prove, wherever this plan has been adopted, or where orchards, groves or hedges exist near the road on the side from which the wind prevails, that banking occurs to a much less extent.

Tree planting is not required for this special purpose only, but it is of great importance otherwise to the country. The rapidity with which the older townships are being stripped of the forest is alarming, and no time should be lost in restoring that protection from exposure which is proving so injurious. The severe gales of winter, uninterrupted in their course, are trying to man and beast. They are destructive to fences, orchards and buildings. Trees interrupt the air currents and moderate the severity of winter gales, protecting inhabitants, stock and property. They arrest the moisture gathered up by free currents of wind in summer. They tend to modify the extreme rays of the sun which frequently, during long, dry seasons in June and July, cause so much injury to vegetation. They relieve the parched and dusty appearance of the country in summer, and break the dreary monotony of the winter landscape.

CONVIOT LABOR.

The employment of prison labor in the work of highway construction is a matter frequently suggested in connection with the road reform movement. Convicts have been employed in this way in a number of the American States, notably North Carolina, where the system is said to operate with a considerable measure of success. In New Jersey, Florida, Delaware and California, prisoners are employed to some extent.

Were provision made for such a measure in this province there is little doubt that much might be gained in the advancement of road improvement. There are two classes of convicts—the short term prisoners confined in the county jails, and those confined in the provincial penitentiary at Kingston. If the latter of these, the Kingston convicts, were employed in quarrying and crushing stone, the cost would amount to about 35 cents per cord for use of machinery, explosives, fuel, etc., but not including the maintenance of the prisoners. The railways, which would be greatly benefited by roads such as will permit a more regular traffic, will doubtless be willing in Ontario, as in the United States, to transport the road metal at actual cost. The price of crushed stone could in this way be reduced very materially for many sections of the province, where road improvement is handicapped largely by the difficulty of obtaining suitable road metal. With railway transportation at a cost of \$1.00 or \$1.50 per cord, this, with the cost of quarry-

ing and crushing and handling, would bring the cost of the product at any railroad station, siding, or perhaps road crossing, to \$2.00 or \$2.50 per cord. This does not include any provision for the purchase of the quarry or the maintenance of the convicts, which are items generally borne by the state.

The prisoners confined in the county jails might, in some cases, be employed in the preparation of gravel or broken stone. Or, as in North Carolina, they could be given the work of grading, draining and spreading the road metal. With the latter course, there is an expense incurred in guarding the prisoners. Some counties have too few prisoners to warrant this expenditure, but in some cases arrangements might be made to collect the prisoners of several adjoining counties for the work. A county jail, fortunately, is usually in the most important town of the county, and the roads radiating from it are those which must support heavy traffic and, consequently, are those most in need of such work as prison labor could perform.

Prison labor in highway construction is advocated on the ground that it would thereby be withdrawn from competition with regular employments and legitimate factory labor. It is a healthful out-of-door work, and, with the majority of convicts, would be of decided physical and moral benefit. With tramps and vagrants, the measure is one which exerts a very deterrent effect.

The state's relation to prisoners is one in which revenge has no part. The object of legal penalty is the prevention of crime, and the object of punishment should be the reformation of the prisoner. The employment of convicts, in prison garb on the highway, is opposed by some on humanitarian grounds, with the belief that the effect on the public and prisoners alike would be injurious to morals. This, however, is a consideration on which the opinion of penalogists will be of value. From the standpoint of one interested in highway improvement, there can be little doubt that with the Kingston labor and the labor available from the jails of large cities, much might be accomplished.

THE ARTISTIC TREATMENT OF COUNTRY ROADS.

The artistic treatment of roads is a matter in which we have been entirely deficient; more than this, the beautiful has been neglected and sacrificed even when it might have been retained without additional labor and with no loss of the useful. Whatever beauty the country highways of Ontario possess has been bestowed upon them by nature in such a manner, seemingly, as to defy the ever militant hand of the despoiler. For an explanation it is only necessary to remember that the construction of roads in the province has scarcely yet passed out of the hands of those who hewed the first wagon tracks through the wilderness, and who are constantly engaged in a stern struggle for the bare necessities of life. It is no cause for surprise that, choosing between the useful and the beautiful, the former has invariably gained the ascendancy. There is a very prevalent but mistaken idea that anything which savors in the least degree of the ornamental in road-making belongs only to the city boulevard.

To what extent the treatment of a roadside should be conventional must depend on circumstances. The most of us can recall with pleasure some roadway leading through a thinly settled, swampy lowland, and closely bordered with woods. There are very few who would wish to so vandalize the works of nature as to go with a scythe among the golden rod and asters, the flags and the grasses that fill the angles of the moss-grown rail fence. Nor would we hew away the ivy-grown stumps, nor replace the picturesque snake fence with one that is "neater." Passing, however, from the region of log houses, with their forest-encircling clearings, to the location where handsome stone and brick country villas predominate, where the woods have been almost obliterated and the fields have been brought to a condition of perfect cultivation, we must give the Queen's highway a corresponding degree of attention to bring it into harmony with its surroundings.

A century ago the first highways of any importance were laid out in the province. The forest was then the enemy alike to agriculture and roads, and the pioneer settler quickly learned, too, that it was the foe to his own means of sustenance. To-day we may, in many localities, pass farm after farm without seeing any of the original trees remaining or any new ones planted for ornamental purposes.

Trees are a necessary adjunct to a beautiful highway. To make this unqualified statement causes a civil engineer to feel some tremors of conscience, accustomed as he is in this utilitarian age to study only the economic side of construction. Trees are, as a rule, anything but a benefit to a roadway. Masses of foliage and shade, so grateful to the traveller, keep the driveway constantly damp—the bane of good roads. If, however, beauty is desired at the expense of utility, highways can scarcely be too much shaded by over-arching boughs. The happy medium will suffice in the majority of cases, and the evil effect of an avenue of trees will be more than made up by the additional pleasure obtained. Trees, however, need not be planted very close to the carriageway, but may be within the private property, or, if on the road allowance, as close to the fence as practicable. The branches should be trimmed so as not to materially interfere with the paved carriageway.

The varieties of trees suitable for the ornamentation of highways in this climate are almost infinite. Maples are most commonly used in Canada, and so universal have they become that many trees having equal or greater claims for beauty are overlooked. The elm, with its graceful, arching branches, and delicate lace-like foliage, is unsurpassed. The oak, renowned in England, is rarely used here. And so we might enumerate walnut, butternut, hickory, beech, chestnut, poplar, pine, ranging from the most delicate to the most sombre and rugged, each more or less adapted to particular requirements and circumstances. Trees such as the willow, the roots of which spread extensively or seek water, should not be permitted to grow near tile drains, as the small fibres, entering the tile, are a frequent source of obstruction.

The matter of fences is a very puzzling one. We have not yet found a shrub that will enable us to copy the hedge rows of England; and to stretch a few strands of wire is easier than to construct a stone wall. Masonry is very common in England and in the New England States. Only occasionally may it be seen here; and when overgrown with Virginia creeper or other vines the effect is all that can be desired. The wire fence appears to suit the present stage of road improvement; and in sections of the province where snow is apt to drift during a part of the year there is sometimes no alternative. Where wire is used, however, a very trim appearance may be maintained; and if the fences are made so as to be as inconspicuous as possible, and a generous use is made of trees and shrubs, the result will not be at all disastrous.

Our system of surveys, which lays off concessions in parallel blocks, with the roadway a rigid line of demarcation, and places cross roads at regular intervals, is responsible for the many cuts and embankments which mar the appearance of the highways. Could roads be laid out as are railways, in a manner that would permit the most convenient route to be taken, much more frequently would we follow pleasant, winding lines and graceful curves. Not only would roads laid out in this manner be more cheaply made, and more artistic in every way, but they would in many instances be shorter. The curve which we make in going down into a hollow and up again, or up a hill and down, is sometimes greater than the horizontal curve that would enable us to avoid the hill altogether.

Very common is the belief that in order to have a beautiful highway an expensive form of paving material must be used. The ideal roadway is of crushed stone or gravel, such as is found in the parks of large cities. A popular feeling is that asphalt has a better appearance than these materials, but this is largely due to the fact that the possibilities of gravel and crushed stone are seldom understood. Horsemen and wheelmen are unanimously in favor of macadam roads, and but very little study of the question is

needed to convince one that only when traffic becomes so great as to render the maintenance of gravel or crushed stone roadways impossible, or excessively expensive, asphalt need be used. So that its domain is the busiest thoroughfares of cities.

It is imperative, however, that the driveway shall be as perfect as possible. We are forced to form our ideas of the beautiful largely from the associations with which we clothe an object. It is difficult to harmonize with our conception of beauty a swampy roadway, into which the wheels of our carriage may have on some dismal autumn day, settled immovably, or over which, if walking, we were compelled to carefully pick our way, in danger with each step of sinking to our shootops in mud. Poets, it is true, find their inspirations in such country lanes; and a driveway which is largely a pool of water doubtless gathers and reflects the shadows which the painter uses so effectively in his pictures. Roads, however, are not for the exclusive benefit of poets and artists; so that the work of increasing their utility will continue.

The roadside, further, must be shaped and, above all, covered with rich sod. No simple or definite rules can be laid down for this portion of the treatment of highways, and the best law-giver in this respect is nature. Nature does nothing stiffly, with rigid and abrupt lines, but has an infinity of gradations and shadings. An attempt to obtain a perfect level will be futile, and we would only secure awkward grades and stiff transitions. Long, easy, swelling lines should be sought.

The science of roads is principally a matter of drainage. Not that the shaping of the roadway, the gravel covering, and other details are unimportant, but that these are a part of the system of drainage. The deep, dangerous and unsightly open ditches that are so frequently to be seen on either side of the roadway, however, are a great impediment to beauty, and must, in the artistic treatment of our highway, be replaced by under-drains of common field tile, which expedient affords an inexpensive remedy. Shallow gutters must of course be provided to carry away the surface water, but they need not disfigure the highway.

A great mistake is made in grading into a carriageway too wide a portion of the road allowance. For the great majority of the country highways in the province, twenty-four feet between gutters is ample, the central eight feet only being macadamized. We admire of course, broad and smoothly rounded driveways, but wide stretches of sod are equally handsome. The driveway must not be confounded with the road allowance, the statutory width of which is sixty-six feet; and this for artistic effects, as well as on sanitary grounds, should never be less, preferably greater.

In no particular are there better opportunities for the artistic treatment of highways than in the class of bridges and culverts employed. The introduction of steel for this purpose permits us to do away with the clumsy and awkward wooden structures which so seldom in their youth are pleasing, and which in old age become grotesque rather than picturesque, replacing them with bridges that are graceful and slender, but strong. Substantial arches of stone are, beyond question, the handsomest that can be employed, their great strength and durability appealing forcefully to one's aesthetic feelings.

To render our highways beautiful at a stroke is an herculean task not to be attempted. To impress upon a certain section of the community the value of beautiful highways is the first step in the much needed reform. Having thus gained the point at which this class of improvements will be systematically brought about, the beauty of the highways will in their turn teach the people their desirability. Men are instinctively better citizens for being surrounded with that which is pure and beautiful. The artistic treatment of highways would be a constant reproach to the shiftless; neglected lawns would become fewer; ramshackle houses and barns would be less common; the eye refreshed and educated at every point, a journey along our country roads would mean to us a journey into a vast park.

DEVELOPMENT OF ROADS IN ONTARIO.

The story of a nation's highways is the story of a nation's progress in civilization, wealth and commerce. A country which has no roads is the home of the savage; a country, the roads of which are typical of the highest stage of engineering science, has attained an equal standard in other branches of refinement. A review of the development of roads in Ontario, as with the roads of other civilized lands, takes us back to the period when the province was a portion of "darkest" America, covered with a primeval wilderness, peopled by that unfortunate race of which but a fast decaying remnant remains.

An Indian trail was merely a path winding through the wilderness. Obstacles were avoided in preference to removing them, and so we find the trails encircling swampy lowlands, or places subjected to inundation, or such ground as would be likely to retain a footprint—a matter of serious moment to the secretive nature of the American savage. The trails passed through dense thickets of underbrush and over fallen logs. Streams were forded, for there were no bridges. They very commonly followed the line of the lake shores and the valleys of rivers. The more important were portages between the head waters of streams. Along these the Indian carried his birch canoe, by means of which he ascended and descended rivers in making his journeys. The most frequently travelled trails became worn by the habitually stealthy step of moccasined feet until more or less distinct, but others were scarcely to be distinguished even by the observant eye of an Indian, to whom a turned leaf, a broken twig or a displaced stone was ample guide post.

The most important of these routes, frequently referred to by early writers, led from Burlington bay to the head waters of the Thames, down which the traveller might descend by canoe to Lake St. Clair. A branch of this trail, mentioned by Galinée, led from the ford at the Grand river to Long Point. An early map shows an Indian path following the north shore of Lake Erie. Trails led from Lake Erie to Chatham and London. From the northern branch of the Thames, a short portage and canoe route led to Lake Huron. A trail led from the Don to Burlington bay. Nottawasaga Bay was reached from Lake Ontario by the Trent valley; by the Don or Humber and portages to Lake Simcoe, from which several routes might be taken. One of these last led from Kempenfeldt bay to the Nottawasaga river; another passed by way of the River Severn.

The first explorers, traders and settlers who entered this portion of Canada, in the absence of roads, had to adopt the methods and means of travel used by the aborigines. Champlain, who in 1615 made the first tour of discovery, went by canoe up the Rivers Ottawa and Madawaska, across Lake Nipissing, and thence by the French river to Georgian bay, a journey which necessitated about forty portages. This was the route generally chosen by fur traders for many years. Champlain, from Georgian bay, reached Lake Ontario by the Trent valley trail. The pioneer settlements were located around the forts at Detroit and Niagara. The United Empire Loyalists, who were among the first to enter the province, about 1785 began to make clearings along the River St. Lawrence, the Bay of Quinte and in the vicinity of Niagara and Detroit. Those who went inland usually chose property so situated that they might reside near a stream, down which in summer they could journey by canoe, and which, when frozen in winter, afforded a convenient means of travel on the ice. Others frequently located in the vicinity of an Indian trail. As the number of settlers increased the trail became a bridge path, then a wagon track, and ultimately resulted in one of the many "trespass" roads of to-day.

The first serious attempt at road construction in Ontario was commenced immediately after the separation of Canada into the Upper and Lower Provinces in 1792, and was one of the chief considerations of Lord Simcoe upon his arrival as the first Lieutenant-Governor. At the first Parliament in 1793, a statute labor law was passed, in spirit very similar to the present law. Guided by his military ideas, which prompted him to see in the present site of London the future capital of the Province, in Chatham a naval dock yard, in Turkey Point and Penetanguishene, naval stations, he accordingly planned a system of military routes. When on one of his tours of exploration he stood on the present site of London, then known merely as the "Forks of the Thames," in the midst of

an unbroken wilderness, and proclaimed his intention of opening a road "straight as the crow could fly" to the Head of the Lake (Burlington Bay). Work was commenced on this road on September 10th, 1793, by a detachment of the Queen's Rangers. This was first called Dundas Street, but is now known as the Governor's Road. From the Provincial seat of Government, York, now Toronto, Yonge Street was opened to Lake Simcoe by troops, a work which was completed in February of 1796. It was the intention of Simcoe that the road through the Province from York to Kingston should be opened by the settlers, and travel from the latter place to Montreal was for a time to be by water. Had Simcoe remained as Governor, it is altogether probable that the work of opening roads would have been carried on more energetically, but with his recall in 1796 ended very largely the era of military construction.

The *Canada Constitution* of September 13th, 1799, contains a reference to the settlements of that period between Burlington Bay and the Thames, in which it says:—

"The settlement from the head of the lake began about four years ago, excepting the Mohawk village; in this period townships have so far increased in population and cultivation that there are several neighborhoods at convenient distances until we come to the mouth of the La Tranche or Thames. . . . These settlers being aware of the importance of roads in raising the value of their property, early set about to open and extend them; notwithstanding the numerous discouragements, and the immediate necessities of their families, they, in one year, at the expense of Mr. Ingersoll, cut and bridged a road from Burford to La Tranche, through a wilderness of twenty-five or thirty miles. This was done previous to the escheating of the townships. Mr. Elijah Putman, of that town, (Oxford), by subscription, has since continued the road thence thirty miles to Allan's (Delaware) township. Here is a villa, and a church raised and now finishing by Mr. E. Allan after the model of that at the Mohawk village. The subscription being very inadequate to completely finishing the work, it was left unfinished but passable for sleighs. He has been by no means discouraged, but issues a subscription to cut a road from Allan's to the Moravian Grant, a further distance, as it must run of fifty miles, to be ten feet wide, and the logs laying crossways to be cut twelve feet long. Without waiting the issue of the subscription, and relying on the patriotism of his neighbors and gentlemen in other parts of the Province who hold lands upon the river, he began and has already opened half the distance, and promises, if the liberality of his friends be equal to it, that he shall immediately complete the whole. The Moravians will extend it seven miles when it shall form a junction with the old road, from whence there will be a good wagon road forty miles to the mouth of the river. Thus we shall have by the ensuing winter a land communication with Detroit and not a day's ride without settlements. Such is the enterprise of our western inhabitants, that one hundred and fifty miles is made without the least allowance from the Government."

The foregoing chronicles the origin of the present London and Hamilton Gravel Road and a portion of the Longwoods Road. It is altogether probable that the former followed in part, the famous Indian trail leading from Burlington to the Thames. The forest along the Thames, from which the Longwoods Road derived its name, extended thirty-five miles westerly from Delaware. This road was improved by troops during the war of 1812-15 so as to permit the transportation of military stores and artillery.

The location of most of the early roads has been very much altered from time to time for the purpose of straightening them or to avoid hills or fords. Thus in 1831 the Longwoods Road was altered in Ekfrid so as to avoid six fords on the Ten-mile creek and two on the Eighteen-mile creek. A map contained in the "History of Scarborough," by David Boyle, illustrates the many changes which have almost imperceptibly taken place in the route of these old trespass roads.

The Danforth road was one of early prominence. Of it, the *Gazette* of April 13th, 1799, says: "The contracts for opening the road between this place (Toronto) and the Bay of Quinte are entered into; the road will be thirty-three feet wide, creeks will be bridged, swamps, etc., will be causewayed, the whole to be completed by July, 1800. A circumstance highly beneficial to the town, and what ought to draw from the inhabitants

the warmest expression of thanks to the Government, as the expense is paid by it." Again the *Gazette* of December 14th, 1799, contains the following: "The road from this town to the Midland District is completed as far as the township of Hope, about sixty miles, so that sleighs; wagons, etc., may travel it with safety. The report which has been made to the Government by the gentlemen appointed to inspect the work is highly favorable to Mr. Danforth, the undertaker, and less imperfection could not be pointed out in so extensive a work. The remaining part will be accomplished by the first of July next." Tradition says of the very crooked line followed by the Danforth road, that Mr. Danforth, being paid by the mile, wished to make the road as long as possible. It is more probable, however, that it followed the irregular windings of an Indian trail.

The road from Toronto to Burlington Bay through the Mississauga Reserve, was for many years merely a trail and difficult to travel. With the opening of Dundas street this trail was lost, but the location is roughly indicated on a map attached to an Indian treaty. This, with the Governor's Road and the Longwoods Road to the west, and the Kingston Road to the east was esteemed an important trunk line through the Province; and with Yonge street to the north, and the road around the head of Lake Ontario to Niagara, were the most important of the early roads.

The roads between Burlington and Niagara was interrupted by the "Black Swamp." A subscription list was opened with considerable success as the following announcement from the *Gazette* of March 15th, 1798, indicates:

"The trustees respectfully inform the subscribers and the public at large that there are 387 rods causewayed and 240 only remain undone, which at one and one half dollars will make 360 dollars. Thus that tremendous Black Swamp bridge, that has been estimated at so many thousand dollars and calculated to take up so much time, has been nearly two-thirds done in about one month, that too in a severe winter. Upper Canada cannot boast a work of the kind so far advanced in so short a time. Three hundred and fifty dollars more, gentlemen, and the work is completed. The money that has been subscribed being all expended, the trustees hope the subscribers will be good enough to pay into the hands of either of them, their respective donations, and further donations will be thankfully received and carefully expended."

By 1796 there were roads from Montreal to Lake Francis, and from Cornwall to Prescott. The intermediate stage of about fifty miles was travelled by boat owing to the wet water-front in Glengarry, and the consequent difficulty of constructing a road. As late as 1807 the mails were carried from Montreal to Toronto, Niagara and Amherstburg by pedestrians who carried an axe to assist them in the journey. In 1816 the first stage was run between Montreal and Kingston, and in 1817 a stage ran between Kingston and York. This, however, was only in the winter, and during summer navigation the stages were discontinued. In 1826 the first stage passed between Niagara and Toronto, and in 1828 a stage route was established between Ancaster and the Detroit River.

In the early history of Ontario, certain provincial roads, such as the Talbot Road, the Sunnidale Road and others, were laid out and administered by the Surveyor General. A great number of the roads first surveyed are supposed to follow the lines of Indian paths. The first Roads Act was passed in 1803. Under this, commissioners were appointed by proclamation of Lieutenant-Governor Peter Hunter, to have charge of their construction and maintenance. By an Act of 1810, that of the 1803 was repealed and the quarter sessions given control of the roads. Colonization roads as now understood were first authorized by an order-in-council of 1848, to be constructed under the Commissioner of Crown Lands.

The first statute labor law of 1793 provided that every landholder or free-holder might be required to work on the roads from two to twelve days, as directed. This was soon found to be unjust, as landowners possessing an entire township were in this way taxed no more than a person owning a few acres. After a few years, a scale was arranged according to assessment, which was afterwards varied from time to time. The work of opening roads was retarded for a time by the clergy reserves, also by the absentee landowners who were not at first required to perform road work.

An Act of 1829 authorizing the formation of the Dundas and Waterloo Turnpike Co., was the first Toll Road Act. The Joint Stock Companies' Act of 1849 greatly fostered this principle and permitted many of the main roads to pass into the hands of private companies to be operated as toll roads. Before the union of the Provinces in 1841, a considerable part of the revenue was spent on roads and bridges. It was estimated in 1840, by Chief Justice Robinson, that £200,000 had been thus appropriated. The system of making provincial grants was abused, however, dissatisfaction was created, and it was found necessary to place the roads entirely under municipal control.

Attention began to be diverted from roadmaking by the construction of canals, the first canal, the Welland, being opened in 1824. The railway legislation of 1849-52 whereby over 1,300 miles of railway were, before the close of 1860, built and equipped at a cost of about one hundred million dollars, also withdrew a great amount of energy from highway construction.

The first roads opened were usually so obstructed by stumps and logs that they were merely winter roads, passable only for sleighs, when deep with snow. The troops, in opening the Governor's Road, chopped off the stumps close to the ground with an adze. Col. G. T. Denison, sen., when opening Dundas street between Toronto and Burlington, took the more radical course of tearing the stumps out by the roots. The Goderich Road opened for a distance of about one hundred miles through the Canada Company's lands was regarded by Sir John Galt as the one undertaking of which he might be proud. The cost of this work was \$5,000, no inconsiderable expenditure in Ontario at that time. In 1825, William Lyon Mackenzie described the road between Toronto and Kingston as the worst human foot ever trod. The Talbot Roads were commenced shortly after the coming of the Hon. Thomas Talbot in 1803, and, extending ultimately along the north shore of Lake Erie from Niagara to Detroit, became noted for their excellence.

Excellence at that time, however, was not what would be now regarded as such. The corderoy road on low and swampy land was the common means of overcoming the absence of drainage. The spaces between the logs were not always even filled with earth, so that the legs of horses were occasionally broken. Roads between dense walls of forest which shaded the roadway and kept it moist, the roadway itself composed largely of vegetable mould—such conditions could not but produce the discomfort and hardship experienced by the early travellers. It was only when the corderoy roads, the bogs, stumps and logs were covered with snow, that journeys could be made with comfort. When the frozen rivers could be travelled with sleighs, the height of luxury in Canadian travel was obtained.

A review of the development of roads in Ontario draws attention to the fact that they have by no means been built by statute labor alone. The pioneers, as a part of their settlement duties and quite distinct from the statute labor, were required to clear the road allowance of trees and remove sufficient stumps to permit a wagon to pass. It was as easy to build the corderoy roads where needed as to adopt the remaining alternative of burning the logs. The stumps not taken out as part of the settlement duties in providing a wagon track, were left largely for time and nature to destroy. The necessity for roads was so urgently felt, that labor and money were voluntarily subscribed, as instanced by the London and Hamilton, and Black Swamp roads, to which reference has been made. The regular troops and militia was employed in opening and constructing roads. The Canada Company opened a number of important roads through the Huron tract. Extensive provincial grants were made from time to time for opening new roads, and for the improvement of roads already opened. Later, many of the main highways became toll roads, maintained by private companies, permitting the municipalities to withdraw the statute labor from them and devote it to the less important roads. Since the roads have been under local control, they have been the object of large and constantly increasing annual money appropriations from the township and county funds. The road improvement which can reasonably be credited to the statute labor system consists mainly of a little grading and a little gravelling, neither of a very high order. So that, for the construction and maintenance of highways in this Province, we have been very much less dependent upon statute labor than is now popularly supposed.

PART II.

TOWN STREETS.

STREET IMPROVEMENT.

The improving of town streets is a question of considerable importance. The majority of the citizens of every town, the best and most progressive men of the community, understand the value of improving the appearance of private residences and lawns, their places of business, the churches, halls and public buildings. Work of this description is unfortunately handicapped in most Ontario towns by the neglected condition of the public thoroughfares. Instead of furnishing, as they should, an incentive to the improvement of private property, they are a constant object lesson in shiftlessness. Improved streets quickly pay for themselves in the encouragement they give to the making of better lawns, and the erection and better maintenance of houses. Well made roadways with boulevards nicely sodded and levelled, sidewalks in good repair, fences removed and trees abundant, give an air of prosperity to a town which is a constant source of pleasure to the citizens, and most favorably impresses a visitor.

A street properly constructed, and paid for in say ten years, is by no means a worn out property. The boulevarding, the grading, the draining and the foundation should be as good as when first constructed. It will remain merely to keep the surface in repair. A street designed on proper principles is, in its ultimate cost, a measure of economy, and will in the end decrease taxation. There are those who ask what revenue is to be derived from street improvement. If the increased property value is not sufficient, the same argument will largely condemn waterworks, sewers, sidewalks and almost any other public work. So long as streets are necessary it will pay to build them well. The majority of people still form their opinions from external appearances. A man's character and influence are largely judged from the house he lives in. On a larger scale a town is subject to the same criticism.

The majority of towns in Ontario pay for work on streets by making annual appropriations from the general funds of the municipality. The amount varies greatly with the different towns, according to the size, wealth, requirements and liberality in this respect, ranging usually from one to ten thousand dollars. This money is distributed over the town in several ways. In some cases it is sub-divided among the wards; the basis of this may be the assessed value of the property in each ward, or it may depend on the skill of the ward representative in wire-pulling. In other cases the ward boundaries are overlooked and the money is divided as the council may deem advisable; in this instance, influence is usually brought to bear directly upon the council by individual citizens or bodies of citizens.

In whatever form, the final tendency of this method of making expenditure invariably is to scatter the appropriation over the whole street area, not in accordance with the actual improvements needed, but according to a councillor's idea of equity, modified by his desire to retain or gain the support of his constituents. The manner in which the appropriation is spent makes it a sort of legitimate election fund; the people expect it and the council has no other course to pursue. The character of the work done is merely temporary patchwork, an effort to keep in repair mud roads and gravel roads which have never been suitably built. No durable improvements are attempted, and the plans are

usually those belonging to townships, as they are commonly developed by a bad phase of statute labor. While such roads are the cheapest in first cost, they are the most expensive to maintain.

It is impossible to condemn in a manner too pointed, the inefficiency of this system of providing for the improvement of streets, a fact made apparent by their wretched state. It is difficult to find a township, with a scattered and scant population, which has worse roads than the average town, notwithstanding the greater ability of the latter to pay for the proper construction of a comparatively short street mileage. A good system of street management must embody two ideas:

- (1) Capable oversight, so that work will be performed on proper principles, of construction and in accordance with carefully prepared plans.
- (2) The concentration of funds so that work of a permanent nature can be undertaken.

In accordance with the foregoing, the first requirement, in the most of towns, is a capable street overseer. He should possess a good knowledge of the principles of road and street construction. Whenever work is to be undertaken, he should first report on it to the street committee, or Board of Works, with plans and specifications. The committee having rejected, accepted or amended this report, the council should sanction or discard it. Work should be carried out under the direct supervision of the street overseer, preferably by contract labor, if the extent of the work warrants it. The overseer should be in constant touch with the chairman of the Board of Works, and should be available at all times for consultation, attending all meetings of the board for this purpose. The necessity of such an officer has been pointed out in connection with township work. His position should be as secure as that of the average clerk or treasurer. Work left to the direction of councils and councillors, with their conflicting interests and ideas, cannot be efficiently performed.

If the system of making annual appropriations is adhered to in carrying on street improvement, the disposition of the money should be such that a certain amount of permanent roadway will be built every year, devoting the smallest sum possible to repairing unimproved streets. This, however, is not the business-like policy, the policy on which great enterprises and improvements have been most successfully and economically brought about.

One man never undertakes to build and pay for a railroad, but a company is formed, bonds are issued, the money obtained to be paid back in the course of a number of years. The work as soon as finished is an asset, to be balanced against the bonded indebtedness. The company which manages and directs the railroad expects it to earn a sufficient revenue to keep itself in repair, and to ultimately pay for itself. This is the method whereby all our greatest and best business concerns have been built up. It is the only method whereby permanent and durable results can be economically obtained. This is the method adopted in establishing municipal waterworks systems, electric light and sewer systems, and is quite as necessary in street improvement. The annual taxes should be used to pay for the interest, for maintenance and to create a sinking fund to meet the principal when due. Improvements made and maintained in this way are not a direct financial loss. But these improvements are an asset to be placed to the credit of the town, to be balanced against the bonded indebtedness just as is the case in the construction of railroads. A town which owns a public hall worth \$20,000, as a corporation is none the poorer because it is in debt to this amount for its construction. The hall is an asset, placed to the town's credit, and balances the indebtedness.

In assessing the cost of these improvements the annual payments may be met by the general funds of the town, in which case, in order to render justice to all, it would be necessary to raise sufficient money to suitably improve at least the most important streets of the town; or a local improvement by-law may be adopted, this being usually framed on the frontage assessment system. Further reference to this system will be found in the appended report to Woodstock. The Municipal Act provides for this system in sections 612-628.

The principle of paying for a public work immediately on its completion is not a just one. The benefit derived from improved streets, a town hall, a sewer system, has only commenced when the work is completed. This benefit extends over a term of years and the only fair system is to ask payment from the citizens as the benefit of the work is received by them.

Nor is the full benefit of street improvement derived when only short sections of street are constructed annually. It is not until the whole town is provided with well designed thoroughfares that the full benefit commences. Short sections are merely scattered links of a chain; the usefulness of the chain is not realized until all the sections are joined, to the full length required. The "pay as you go" system is not the most profitable, if under it the work can be performed in limited sections only.

CHOICE OF PAVEMENTS.

The principle of economic fitness between the paving material and the wear to which it will be subjected, is an important consideration in designing streets as well as country highways. We have to consider the character of the natural soil on which the metal is to be laid—whether loose and porous, or retentive and difficult to drain; whether a light sand or a dense clay; whether stony or close to bed rock. We have to consider the qualities which the traffic over the road will require of the pavement; we must consider the availability of material for surfacing the road, whether economy advises the use of the metal at hand, or the bringing of a more suitable material from a distance.

All kinds of pavement are good when laid in the right way and in the right place. It is useless to condemn without proviso any one variety of pavement, for however defective it may be found under one set of circumstances, under other circumstances it is altogether probable it would be the most economical and serviceable that could be used. Cedar block is commonly looked upon as an entire failure for paving purposes. Cedar block has failed in a great many instances on account of the weak and undrained foundation on which it was placed. It has failed in other instances on account of the poor material used. In other cases it has failed by reason of a damp and unfavorable climate. It has failed frequently because of the excessive traffic to which it was subjected. While the use of cedar block is not advisable to any great extent in Ontario, yet it is easy to conceive of a dry climate, a loose, porous sub-soil and other facilities for securing a good foundation, an abundance of choice material close at hand, all of which would go far to render cedar block the most desirable material in that locality.

Macadam is pre-eminently the favorite pavement among horsemen, and if properly built is considered by many to be equal in appearance to asphalt. In hot weather it is scarcely possible to subdue the dust on an asphalt pavement by sprinkling, but Macadam can easily be kept moist. Macadam should in Ontario supplant asphalt on residential streets where the traffic is not too great. Brick is not, in appearance, equal to well kept macadam, and should be used on residential streets only when, for economy, a stronger pavement is required, and when the handsome effect of asphalt is not required.

One is sometimes asked for an expression of opinion regarding the relative merits of brick and asphalt, irrespective of the traffic, the climate and other matters affecting their durability. The only reply which one could give to such a question is, that both are good; or to look at it from the other standpoint, both are bad. Brick pavement appears to be the ideal pavement for the business streets of towns and smaller cities. The cost is from one-third to one-half less than asphalt, is not objectionably noisy, does not decay readily in a moist climate, and will support a considerable weight of traffic.

Asphalt is suitable for a business thoroughfare, where a slightly stronger pavement than brick is needed to support a somewhat heavier and more constant traffic. It is suitable too, for a residential street on which there is too much travel to permit the laying of a macadam pavement and where a more costly effect is desired.

The streets of towns in the immediate business portions are subjected to wear not imposed upon residential streets. If broken stone roadways are retained on business streets the gutters should be cobblestoned to protect them from the feet of horses when tied or standing close to the curb, and a covering of one foot in thickness should be used over the whole surface. Macadam is not the most desirable material, however, for this class of street. A pavement is needed which will not absorb street filth, which can be readily cleaned, which will not be dusty, nor muddy.

The choice of pavements for the business streets of towns and cities of Ontario appears to rest at present between asphalt and brick, the former so far obtaining the preference. Cedar block should be used so rarely that it need not be considered in a general discussion of the subject.

ASPHALT.

Asphalt is more noiseless than brick, is smooth, sanitary, and presents a good appearance, but it is not the ideal pavement, in all respects, that it was at one time supposed to be. In summer its smooth, stony surface radiates an intense heat; any amount of sprinkling cannot keep the surface moist so as to allay the dust, while the glare which it reflects on a bright day becomes painful to one driving or walking over it. The wet weather of fall and spring in this climate keeps an asphalt pavement in a very slippery condition, unsafe for horses, while at any time the foothold is insufficient.

The most common causes of the failure of asphalt are found to be weak foundations, which, settling, permit water to stand in hollows on the surface until the pavement is rotted; tearing up the pavement for sewer connections; surface cracks, caused by contraction in cold weather; insufficient traffic and excessive traffic. The destruction of asphalt arises more from atmospheric effects than from wear, a certain amount of traffic being beneficial rather than detrimental.

Asphalt is seldom worn out by too much traffic, the decay generally arising from other causes, some of which have been enumerated, and which the specifications should rigidly guard against as far as possible. A good asphalt pavement should be maintained by the company building it for seven years, and at the expiration of that time delivered to the municipality in perfect order.

VITRIFIED BRICK.

The only competitor of asphalt is vitrified brick. This pavement has come in a most timely way to take the place of the decayed cedar block pavements which are disgracing the streets of so many towns and cities. Vitrified brick is becoming popular, and presents features which tend to cause it to become more so. It offers a better foothold for horses than does asphalt. The surface is not so smooth, and in consequence radiates less heat and light, is quite as sanitary, with less liability to become dusty. Among bicyclists it is much more popular than asphalt. If the joints are filled with suitable cement, brick pavement is but little more noisy than asphalt.

The majority of failures which have occurred with brick, have been traced to defects which the material or better construction could have obviated. Its ease of construction and repair offers a great advantage over asphalt, ordinary laborers being easily taught to do the work. Few repairs are needed if good brick is used, and in the first cost as well as in maintenance, brick should be, and generally is, cheaper than asphalt.

Although brick is one of the oldest paving materials, it has been used on this continent for only about a quarter of a century; and only within the last ten years has it attracted widespread attention. In the United States, it has been used very extensively, but in Ontario, experience with the modern vitrified brick is very limited.

Of its success as a paving material little remains in question. Brick pavements have been in existence in the United States for eighteen years, remaining in good condition. It was feared that the climate of northern countries with severe frosts and rapidly alter-

ating conditions of moisture and temperature, would be unfavorable to its use, but the experience of various northern cities shows that vitrified brick of a good quality is a most valuable addition to our list of paving materials.

The best vitrified brick is made of shale or clay, or a mixture of the two. It is not "vitrified" as the name indicates, but is raised by intense heat just to the point of fusion. More than this fuses or melts the clay, permits it to run together and the product is then glassy or vitrified, and brittle in consequence. The process of cooling must be very gradual. A brick if too rapidly cooled or "annealed," will be brittle, but with a thoroughly pulverized and well-mixed shale, brought to the proper temperature and then slowly annealed, the resultant brick should be sufficiently hard and tough to scratch steel.

The chemical composition is a matter of importance. The chief defect is likely to arise from too much lime. Brick which contains an objectionable amount of lime, or other soluble substance, when immersed in water for three consecutive days, and then kept in a dry atmosphere for a corresponding length of time will show signs of spalling and pitting, and indicate a faulty composition of the clays of which they are composed.

When broken, brick should show a smooth and straight fracture, and the texture and color should be uniform throughout. A granular appearance is very objectionable. Bricks externally should be smooth and straight, not warped, and should be free from fire cracks and checks.

Brick should absorb the least possible amount of moisture. A large amount of water in brick, freezing, has a bursting effect which in this climate cannot be guarded against too carefully. A good brick will not absorb more than two per cent. of its weight in water. To absorb three per cent. may be permissible if in other respects it reaches a high standard.

The quality of brick is fairly well shown by the rattler or tumbling barrel test, as this most nearly approximates to the wear from the blows and chipping of horses feet. A tumbling barrel or rattler consists of a cylinder about three feet long, and two feet in diameter, placed on a shaft. Samples of the different makes of brick are first weighed and are then put in the barrel, together with from 150 to 300 pounds of scrap iron in from two to eight pound pieces. The rattler is then revolved for two or three hours at the rate of about thirty revolutions per minute. The comparative loss in weight will indicate the relative efficiency of the brick in resisting this class of wear.

A valuable test is that of transverse strength. In this the brick is laid upon two knife edges, placed about six inches apart. An upper knife edge centrally between the two lower blades is slowly brought to bear on the brick, and the weight required to break it is carefully noted.

Other tests are sometimes used, to determine crushing strength, the depth to which oil will penetrate the surface, etc. The specific gravity of a brick is valuable as indicating density, and therefore the extent of probable absorption. The chief tests, however, are those above described; that of absorption, representing the probable effect of atmospheric action; the rattler test, showing the effect of impact and abrasion as found in the chipping of horses hoofs and the grinding of wheels; the transverse strength, showing the power to resist the breaking strain of heavy loads. Where, in towns, the facilities for performing these experiments are not available, and only short sections of pavement are to be constructed, the experience of cities will generally afford a safe guide in choosing between different makes of brick. A further safeguard may be had by requiring the contractor or manufacturer to maintain the pavement up to a certain standard for at least five years.

There is a tendency to endeavor to reduce the cost of brick pavements by the use of a weak foundation or no foundation at all. Brick pavements laid on gravel and sand have been successful, but this has been the case only when the subsoil has been of such a kind as to be very porous, easily drained, and naturally firm. The experiment in Ontario, in view of fall and spring conditions with alternate freezing and thawing, is a very dangerous one, a lesson which has been strongly impressed by the experience with cedar blocks.

While a brick pavement may give satisfaction for a few years on sand and gravel foundations, there is every probability that the brick will settle irregularly, and, rendered thereby more susceptible to wear and strain, the bricks will be broken and the life of the pavement very much shortened.

A concrete foundation should almost invariably be employed. A four inch layer will, where a brick surface is suitable, be sufficiently durable. This forms a stiff monolith base which distributes the weight of traffic. There cannot be irregular settlements of brick, as is the tendency with yielding materials, such as sand and gravel. It also prevents water percolating beneath the road, not a very important feature in the south, but in freezing climates a matter of considerable importance.

Between the bed of cement and the surface covering of brick a thin cushion of sand is necessary. By this means the brick can be laid evenly, a certain amount of spring is obtained which lessens the effect of blows on the brick, and it overcomes the rumbling noise otherwise created. It is a common practice to merely fill the joints of the brick with sand. While this is not at all objectionable, by the use of a cement composed of pitch and sand the pavement becomes less noisy, absorbs less street filth, and corners and edges of the brick are strengthened.

MACADAMIZED TOWN STREETS.

There is a common impression that macadamized roadways are all very well for country highways, but that, for town streets, a higher grade of paving material, brick, or wood, or asphalt is necessary. This opinion, so adverse to macadam, has no doubt arisen from the common practice of terming a "macadam" road, any allowance between concessions that has had an irregular layer of gravel dropped along the centre. This was somewhat the idea the people had of roads before the time of Macadam, the main feature of whose road-making, however, was a firm, unyielding sub-soil, maintained in that condition by a thorough system of deep drainage: and a covering of stone, impenetrable to moisture and so shaped so as to shed water quickly to the gutters. All kinds and classes of paving have their proper place, and, in its proper place, there is none more serviceable or capable of giving greater satisfaction than Macadam.

RESIDENTIAL STREETS.

One place in which macadam can be rightly employed is in paving certain town and city streets—those of a residential character, not subjected to traffic so great as to render the maintenance of macadam excessively expensive. There are, of course other limitations which individual cases will suggest. Business thoroughfares, or a street in its business section, requires a less absorbative material, and one which presents a smoother surface, more easily cleaned. With horses standing, moving slowly, tied and pawing as so frequently is the case on a business street, and generally with an excess of heavy traffic, a macadam pavement retains a great amount of street filth, is difficult to maintain, and should be, if possible, replaced with vitrified brick or asphalt. A well kept macadam driveway is in keeping with well-kept boulevards, lawns and shade trees, the characteristics of a residential street; it has a cool appearance, the dust can readily be kept down by sprinkling, and for light driving is the favorite among horsemen. Bicyclists, now an important section of the community, usually favor macadam, in preference to the more costly classes of pavement. A comparison of macadam with asphalt or vitrified brick, in point of utility and beauty, will not result unfavorably to the former.

GRADES AND EARTHWORK.

Preliminary to undertaking the improvement of town streets, levels should be taken on all the streets to establish a system of grades which will provide a proper union of street intersections. Care should, of course, be taken to equalize cuts and fills as far as practi-

able, and to utilize surplus earth in filling up the boulevards or low lots adjoining the street. In this, the handling of considerable earth is often necessary to obtain the best results.

In the finished street, it is ordinarily advisable to have the crown of the roadway at about the same elevation as the surface of the sidewalk ; and, in any case, the sidewalk should not be lower than the crown of the roadway. It will be necessary to excavate below this elevation in the centre of the allowance to provide for the reception of the road metal. The depth of this excavation must provide for the thickness of metal to be used, and for surface drainage.

WIDTH OF ROADWAY.

The present tendency is to narrow the width of the driveway. It is found that to occupy a 66 foot allowance with a four foot walk on each side, and to devote the remainder to the driveway, is a needless expense, both in cost of first construction and in maintenance. From 22 to 26 feet is, on the great majority of the residential streets of towns, ample to accommodate traffic. A broad driveway is very handsome, but so also are broad stretches of nicely sodded boulevard, ornamented with shade trees.

SIDEWALKS AND BOULEVARDS.

At present, on improved streets, we ordinarily find a row of shade trees outside the walk. In commencing the reconstruction of a street, it is generally advisable, if not necessary, to take up the sidewalk to permit a proper grading of the road allowance. When the earthwork is finished, the sidewalks may be placed immediately outside the row of trees, and the space originally occupied by it, sodded ; and if the fences are removed the strip is, in appearance, added to the depth of the lawn. This arrangement will usually leave a space for a strip of sod between the sidewalk and the carriageway. If this part of the boulevard can have a width of about two feet or more, it takes away a certain dusty, business appearance which the street would otherwise retain. The sidewalk should have a distinct elevation above the sod, sloping slightly toward the roadway, to provide for a proper drainage. The strip of sod between the walk and curb should have a fall toward the curb of six or more inches, and on a 24 foot roadway having a one foot crown at the same elevation as the walk, this will leave from six to eight inches of curb exposed.

THE CROWN.

The crown referred to above, about one inch to the foot, will seem to many, perhaps, excessive. This applies to the newly-made roadway and provides for settlement. Two-thirds of an inch is the convexity ordinarily adopted on newly-constructed English or French roads, but with the material available in most localities of this province it is not sufficient. The limestone, gneiss, field stone and gravel ordinarily obtainable in Ontario are not the most durable, hollows are apt to appear, dust accumulates, and unless there is ample fall for the water, it will be found lying upon the road surface. The tendency invariably is for traffic to use the centre of the roadway, and this is always increased with the narrower driveways. But in choosing between two evils it is better practice to provide ample crown. It is better that travel should be less distributed than that water should lie in pools on the road.

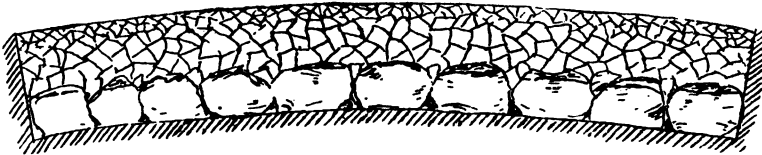
The shape of the crown has been a subject of some discussion. A circular rise is believed to be the best principle to follow in practice. Two planes, joined at the top by a short curve do not provide for settlements and wear. A flat ellipse, sometimes advocated, does not provide for settlement and gives an unduly steep fall at the edges increasing the wear at the side, and practically narrowing the roadway.

CURBING.

For curbing, flagstone, which is easily obtained in many districts, is the more handsome and more durable material. A good substitute is 3x10 cedar, which should be spiked to cedar posts 2½ feet long and 6 inches in diameter. By bevelling the posts the curbing may be inclined at an angle of about 30 degrees. It presents a better appearance than when perpendicular, the tops of the posts are protected and there is less liability to decay.

MATERIAL.

In nearly every locality throughout the province good material will be found within easy distance. Crushed stone is usually regarded as the only material for macadam roads, but Macadam really used and advocated any material which would provide a good wearing surface not readily penetrated by moisture. Thus we have in Ontario a choice of gneisses, limestones, field boulders, pit and creek gravels; or if



CROSS SECTION.

Showing a broken stone driveway, with a foundation layer of flake-stone.

we wish the best material, trap rock is available. Of these materials we have all qualities, from that which is exceedingly good to that which is little better than clay. The gneisses are usually a harder and tougher rock than limestone, but the latter offsets this defect largely by better cementing qualities. Field stone makes a very good metal if care is taken in its selection. Pit gravel usually needs screening and crushing to remove sand and earthy matter and to reduce the large stones to suitable dimensions. Creek gravel is often sufficiently clean to be applied directly to the road but some attention should be given to breaking large stones. In choosing the metal, a judicious selection must usually be made between a cheaper and poorer material in the immediate vicinity and an expensive but more durable metal from a distance. The selection will be based on the expenditure permissible and the nature of the traffic and the quality of stone used. Twelve inches is sufficient for the heaviest travel, and a thickness of seven inches is the least advisable. The coating should be heavier at the centre than at the curb. These measurements are after consolidation with a roller. A fuller discussion of this portion of the subject will be found in connection with country roads.

BINDING MATERIAL *vs.* ROLLING.

The use of binders is another question of considerable importance. The best that can be had is usually the clean chips and dust, the screenings of the metal used. The amount of vacuum in a surface covering consolidated without a binder is very considerable, but the mechanical grasp which one stone takes upon another under pressure is infinitely preferable to the consolidation obtained by a mixture of sand and stone. Sand attracts and retains moisture, while a vacuum will permit the water to pass away, at the same time providing space for the expansion of the frozen water retained. The action of frost on a clean metal is much less serious than upon a roadway having a temporary bond of sand. Rolling is an absolute necessity in obtaining a proper surface covering of crushed stone. Broken stone dropped loosely upon a roadway permits water to pass into the sub-soil as through a sieve and the process of consolidation under traffic not only results in a very great wear and tear of metal, but mixes it with the earth which of itself is very injuri-

ous and in so doing destroys the crowning and therefore the proper surface drainage of the roadway. The sub-soil should be crowned and, like the covering, thoroughly consolidated by rolling. The metal should be applied in layers three or four inches thick, each layer being thoroughly rolled before the next is applied.

THE ROLLER.

The weight of the roller should be from ten to fifteen tons, the former generally producing the better results. An excessive weight tends to crush the metal, especially if of the softer local varieties, instead of working it into position. The heavy rollers produce consolidation more quickly, but the lesser weights have more permanent results. Less than ten tons is not advisable except in the instance of a horse roller, a cheaper but not very satisfactory substitute for a steam roller.

UNDERDRAINAGE.

The necessity of underdrainage has been referred to fully in connection with country roads. The means must usually be common field tile. The location and extent of drainage must depend on various circumstances, the nature of the soil, the opportunity for outlets, and whether or not there is a sewer beneath the roadbed. Ordinarily a three or four inch tile placed beneath the edge of the roadway on each side, and below frost line, is the best rule to follow, but this, if the soil is loose and porous, and has a natural outlet for sub-soil water, may be more than is necessary. A line of tile placed in the centre of the road allowance disturbs the earth foundation, and settlements are likely to occur, a condition which is difficult to repair and is very injurious to the stability of the road.

GUTTERS.

If gravel or broken stone is used on a business thoroughfare, the gutters should be cobble-stoned to protect them from the stamping of horses; but on residential streets this is not necessary, the angle between the road surface and curb forming a sufficient waterway. Outlets for surface and sub-drainage must be procured as frequently as possible so as to dispose of the water before it gains force and headway. If a system of sewers exists, with provision for storm water, the matter is very much simplified. When necessary the water may be admitted to the sewer or tile drain through settling basins which should be very carefully guarded, to prevent obstruction.

The principles of road-making touched upon in this discussion of macadam streets for towns, will be found more fully developed in connection with the articles on country roads.

FORM OF SPECIFICATION FOR MACADAMIZING AND BOULEVARDING RESIDENTIAL STREETS.

In giving the following specification for macadam streets, it is not intended that it shall be rigidly adopted by any municipality. It indicates, however, the form which a specification should take, and may be modified to suit local circumstances.

EARTHWORK.

The excavating and grading is to be made to the depth and width shown on the drawing having preference thereto and to the levels given on the ground by the engineer or the person in charge of the work; and also to such greater depth and width as may be directed, to enable the curbing to be properly set; the levels and cross sections may be varied at the discretion of the engineer or other person in charge of the work, to conform to the elevation of lots and grades of intersecting streets.

The earth taken from the excavation for the roadway is to be used in properly grading up the boulevards and filling in any portion of the roadbed which is beneath the grade line on the proposed improvement; and the surplus earth is to be teamed from one point of the street to another as may be required in making the said boulevards, where there is not sufficient earth, and at any particular point in this excavation to complete the work; and the remainder of the excavated earth is to be deposited wherever directed by the engineer at a distance of not more than 1,500 feet on either side of the said street.

THE SUB-GRADE.

The sub-grade when complete must conform truly to the required cross section as shown on the drawing.

Should the contractor, in grading, excavate below the proper level on the sub-grade, the deficiency shall be made up with gravel or other approved material well sprinkled and rolled at the contractor's expense.

SIDEWALKS.

The contractor is to carefully take up the present old sidewalk and crossings on the street, running in an east and west (or north and south) direction, and deposit the material; and the contractor, where required, shall take up all crossings over the streets running in a north and south (or east and west) direction and pile the material by the side of the intersecting street where it will be out of the way of travel.

The contractor is to excavate, or form in the excavated earth, a trench or opening for the sidewalk feet wide and inches deep. The bottom of the said trench is to be level with the top of the line of the curb except where otherwise directed by the engineer.

All the sidewalks on the said street will be laid down by the contractor for that purpose; but the contractor for grading, etc., is to make the proper excavation as shown on the plan for said sidewalks, and after the sidewalks are laid the contractor for street grading must do any necessary filling or lowering of the boulevards in order to properly meet the grade of the sidewalk.

BOULEVARDS.

The grade of the boulevard at the side of the sidewalk nearest the line of curb is to be six inches above the top of the line of curb. The boulevard between the curb line and the place made to receive the sidewalk is to be regularly bevelled off from the grade line at the top of the sidewalk to the top of the curb. The boulevard between the sidewalk and the street limit is to be regularly and evenly graded by cutting down or filling in as may be required, so as to conform to the grade of the sidewalk, except where otherwise directed by the engineer, in order to conform to the elevation of the lawns along the said street. The boulevards are to be left smooth by raking or otherwise levelling to the satisfaction of the engineer or other person in charge of the work.

TREES.

The contractor, in doing the work, must excavate or fill in around trees on the said street in a careful manner so as not to bark or injure the said trees.

CURBING.

Each side of the roadway throughout the whole length of the street is to be curbed with sound, live, white cedar, mill-made planks three inches in thickness by ten inches in

depth, and not less than twelve feet long, The posts are to be of round cedar, barked, good and sound, having a finished length of three feet, and to be not less than six inches in diameter. The posts are to be firmly set in the earth to a depth of two feet, centre to centre and cut off flush to the top of the curb. The planks are to be secured to the posts with seven inch wrought spikes, three spikes to each plank at each bearing. The planks must be neatly and closely joined, the joints to be made truly to the centre of the posts. The whole of the posts are to be set in an accurate manner, and true to the line and level given, and at such elevation as to show a face of ten inches above the subgrade, and with such incline from the roadway as may be directed.

At each street, lane, alley, private way, etc., the curbing shall, unless otherwise directed, be returned to the sidewalk, the returns to be placed at an angle of forty five degrees with the line of the curbing, each return to have a post where the curb meets the sidewalk. The earth at the back of the curbing is to be properly rammed so as to ensure stability of the curbing. The material and workmanship used must be in conformity with the specifications and plans, and to the satisfaction of the engineer, or other person in charge of the work.

SEWER AND WATERWORKS FIXTURES ON STREET.

Returns and off-sets, if necessary, must be made in the line of the curb around any of the water gullies on the street. The levelling of the top of the sewer gullies, man-holes, etc, and the building up or lowering of all waterworks standpipes in such manner as the engineer may direct to suit the grade and crown of the roadbed, will be done by the contractor.

PRIVATE ENTRANCES AND STREET INTERSECTIONS.

All intersections of private lanes are to be properly made and graded in the boulevard by the contractor at a gradual slope from the top of the sidewalk to the bottom of the gutter, and all street intersections are to be graded to conform to the finished grade of the street.

BREAKING UP THE STREET.

The contractor is to break up the street in such lengths and at such points as may be directed by the engineer in charge of the work, and no part of the street shall be broken or torn up, or no portion of the old sidewalk removed, without the order of the engineer.

WORK TO BE CONTINUOUS.

The contractor will be required to carry out the work continuously from the time of the commencement until the completion of the contract.

RIGHT OF WAY.

The contractor will keep, if so ordered by the engineer, ten feet of the roadway nearest the curb open for use of the public from 7 a.m. to 7 p.m., and will keep the work properly barricaded and protected at night with lanterns.

ROAD COVERING.

The surface of the roadway over the said road is to be covered with crushed stone to the depth of inches in the centre, and inches at the curb, to be regularly and perfectly spread over the whole of the roadbed to a depth to conform to the cross section shown on the drawings, and proportionate to that specified for the centre and curb. The crushed stone is to be furnished by at

PLACING THE METAL.

The whole of the sub-grade, when levelled, shall be thoroughly rolled with a roller weighing ... tons, to be passed over the surface at least times. The roller shall be provided by, the work to be performed by the contractor. Crushed stone of a size to pass through a two and a half inch ring is to be placed over the whole of the surface of the sub-grade to a depth of inches in the centre and inches at the curb, and rolled with the said roller times; crushed stone to pass through an inch and a half ring is then to be placed over the whole of the surface of the road to a depth of inches in the centre and inches at the curb, and this rolled with the said roller times. A sufficient quantity of crushed stone of one inch in diameter, is then to be placed over the whole of the roadbed to bring it to the line of the finished grade as specified on drawings, this to be rolled by passing the said roller over it times. A coating of fine screenings is to be placed over the surface of the road and worked into the interstices of the mass of stone by thoroughly saturating and flooding with water, either from street hose or properly constructed sprinkling carts, and by passing a short harrow over the surface of the whole mass until the engineer is satisfied that the interstices are properly filled. The roller must be again passed over the whole of the road times, or to the satisfaction of the engineer.

WATER.

During the whole of the rolling herein specified, a sprinkling cart is to pass immediately in front of the roller so that at all times the surface of the road will be saturated with water. The water is to be obtained from the street hydrants for which a charge of one cent per lineal foot must be paid by the contractor to the water commissioners.

Sod.

All sod on the street between the curb line and the line of the new sidewalk is to be carefully taken up by the contractor and neatly piled at one side of the work. After the boulevards have been built to the required grade, the sod is to be relaid by the contractor in a perfect manner.

TILE DRAINS.

The contractor is to furnish the tile and construct a four-inch field drain along the inside or roadside of the curb line on each side of the street. The tile is to be placed inches under the subgrade of the roadway, and after it is laid the trench made to receive them is to be filled in with the excavated earth to the surface of the subgrade, and thoroughly consolidated.

EXTRA EXCAVATIONS.

Any extra excavations that may be ordered by the engineer will be paid for at the rate of fifteen cents per cubic yard.

TENDERS.

Tenders are to be made in the form of a lump sum which will be taken to cover the cost of furnishing all necessary material (except stone), implements (except roller), labor, etc., of every kind to complete the work of grading, boulevarding and macadamizing the said street.

PAYMENTS.

Payments to the extent of per cent. of the work done each week shall be made by the certificate of the engineer, such certificate to be binding only as regards progress; and weeks after the completion of the work to the satisfaction of the engineer, the engineer will issue certificate for the balance.

A P P E N D I X .

TOWN REPORT.

To His Worship the Mayor and Members of the Council of the Town of Woodstock :

GENTLEMEN,—Having visited your town on the 19th of October last, in accordance with the invitation extended me, I drove over a number of the streets in company with the Board of Works, examined the methods used in their construction and maintenance, the system of management and expenditure, and beg to submit the following report :

ROAD EXPENDITURE.

Money for this purpose is appropriated from the general funds of the town to the amount of \$2,000 annually. It is distributed among the various wards, and the sum given to each is under the control of the councillor representing that ward on the Board of Works. Under this system the effect invariably is to again sub divide the ward appropriation to such an extent that no work of a durable nature can be attempted. The people expect the amount to be scattered and the council has no other course to pursue. The system is fundamentally bad. Money is not spent in accordance with the requirements of street improvement, and the result is waste, extravagance and bad roads. An annual appropriation from the general funds for the repair of roads is found to work satisfactorily and equitably. To construct roads, however, under this method is practically an impossibility, as the expenditure cannot be sufficiently concentrated.

FRONTAGE TAX.

The most suitable remedy for existing conditions in Woodstock is the frontage tax system. When work is undertaken under it, money is raised by the issue of debentures extending over a term of years. The amount is assessed against the property abutting on the work, or benefited by it, according to the frontage of the lot, or according to its superficial area, or according to the assessed value of the property. Which ever one of these plans is chosen by the council should be stated in a general by-law submitted to the people for the adoption of the system. By means of the frontage tax system sufficient money can be raised to do durable, serviceable and economical work, and it is the most satisfactory method of consolidating road expenditure. Money thus raised is obtained at a very low rate of interest, and payment being extended over a term of years, the annual rate of taxation is small. The ultimate cost is no greater than under the old system of patchwork, the difference being that less money is wasted. The durable improvements obtained are at once a benefit to the individual property owner, the value of property is increased, and the town as a whole becomes a more desirable place of residence.

Under this system work may be undertaken in three ways : (1) On the petition of at least two-thirds of the property owners affected, representing at least one-half of the value of the real property benefited. (2) On the initiation of the council, unless petitioned against by a majority of the property holders affected, representing at least one-half of the property to be benefited. (3) On the recommendation of the board of health for sanitary reasons. In assessing the cost, ratepayers are notified of the amount, etc., and courts of revision are held giving an opportunity to appeal, and to adjust any errors in the assessment.

As has been intimated, a general by-law for the introduction of the system should be submitted to the citizens, and should be sanctioned by a majority vote. In framing this general by-law very great care must be taken to adjust it to local circumstances as far as possible. When this is done, and the by-law provides for a just and equitable assessment, street improvement is invariably stimulated. To this end peculiar cases, such as corner lots, triangular or irregularly shaped lots, side-hills and similar property should be taken into consideration; also the matter of street intersections, which are sometimes paid for by the property owners on the street, sometimes by the municipality. The frontage tax has in some cases unquestionably worked injustice, but when the by-law is judiciously framed there is no fairer way of paying for street improvement.

DIRECTION AND SUPERVISION OF STREET IMPROVEMENT.

In the direction and supervision of street improvement in Woodstock there are very serious defects. This branch of public work is in the hands of the ward representative on the board of works. There are five wards in Woodstock, and each member of the board of works is subjected to the possibility of a change annually. The result of such a system is that there is an entire lack of uniformity in street improvement. The work of one year is generally done without reference to the work of succeeding years, in view of which it may be rendered useless. Almost every street presents instances of this defect, in its sidewalks, its drainage, grade and road metalling. For economical and satisfactory results, there should be someone with a knowledge of the principles of road-making and street improvement over this branch of public work, who would examine, stake out and report to the board of works with plans and specifications; and works of importance should be let by contract. All work should be completed under the supervision of this official. He should be in constant touch with the chairman and board of works, and should attend each of their meetings for consultation. Even if all who have been members of your board of works had been expert road-makers, the constant change and interchange of plans would necessarily result in patchwork.

WASTED LABOR.

A considerable quantity of gravel was being placed on Reeve street, High street, and a number of other streets at the time of my visit, but owing to the poor quality of the material and the method of placing it on the road, the expenditure is practically wasted. A quantity of broken stone has been placed on McQueen street. The sub-soil was not prepared so as to form a suitable foundation and the metal was scattered loosely over the road. Traffic will soon force the stone down into the mud and the result will be very unsatisfactory. A broken stone road built in this way is less serviceable than gravel.

CONDITION OF THE STREETS.

The inefficiency of the system of expenditure and supervision employed in your town requires no other demonstration than the present condition of the streets. Gravel has been heaped on the centre of the road without reference to the objects to be attained in road construction. Very much of the gravel has been of an exceedingly poor quality. The drainage, where there is any, is crude and imperfect. The people have shown a disposition to boulevard the streets, but owing to the absence of a suitable curb line or established grade, these boulevards are undulating and irregular in width and elevation.

It is really a source of surprise that money, drawn from the pockets of the people, should be so long lavished in such a hap-hazard manner. To all other branches of construction, waterworks, sewerage, and public and private buildings, you have given serious consideration, but on streets the object appears to be to spend money. As with other enterprises, street construction, in order to obtain serviceable and economical results, must be treated as a matter of business.

DRAINAGE.

Good pavements are largely a matter of good drainage. Not that the shape of the roadway, the material of which the surface is composed, or the way in which it is laid, are unimportant—but that these are very largely a part of the system of drainage. With the River Thames in the westerly portion of the town, and Cedar Creek passing through the southern portion, with natural depressions or watercourses leading to these streams throughout the town, admirable facilities for street drainage are afforded.

Underdrainage is one of the first points to consider. In making roads it is the native soil which must really support the weight of the traffic, no matter what paving material is used to surface it. Gravel, stone, brick or asphalt are not sufficiently strong to bridge over a wet and yielding subsoil. But if this natural soil is kept in a dry state it can support any weight, and to this end underdrainage is necessary. Underdrainage of common field tile, four to six inches in diameter, should be placed on each side of the carriageway underneath the gutters, and below frost. This "lowers the water line" and secures a good foundation.

There must be surface drainage and for this the roadway should be crowned or rounded up, covered with suitable surface material, and open gutters provided to carry away this surface water. The surface metal (gravel or other material) of course resists wear, but on streets which are lightly travelled the main object is to provide a cover which will prevent the water penetrating the natural soil underneath, making it unfit to support traffic. By crowning the surface of the road, water is shed at once to the side, where provision should be made to carry it away immediately in open gutters.

Gutters or under-drains are useless unless outlets are provided, and care should be taken to see that these do not become obstructed. Surface drains may have outlets into the tile drains through catch basins, or into the sewers, where capacity for storm water is provided.

Springs underneath roadways should be tapped with blind drains and the water carried diagonally to the underdrains at the side of the road.

Cedar street, a leading entrance to the town, receives a great amount of soakage water from the uplying land. A very large quantity of gravel has been placed on this street, but without a complete system of underdrainage the roadway can never be economically maintained.

CROWNING THE ROADWAY.

To secure perfect drainage the roads should be uniformly crowned or rounded. On the streets of Woodstock very little attention appears to have been given to this important matter, as on the majority of streets no crown whatever is made, while in one or two instances, notably Vansittart avenue, it is considerably above the adjoining property, driving the traffic to the gutters and making it almost dangerous to turn from the centre. On gravel or macadam streets this crown should be one inch of rise to each foot horizontal from the gutter to the centre; that is, the centre of a roadway twenty-four feet wide should be twelve inches higher than the outer edge. It is well to first establish the grade of the sidewalk and then make the centre of the roadway conform to this as nearly as possible, and with the same elevation. On hills the crown should be sharper, say one and one-half inches rise to one foot horizontal, so as to draw the water quickly to the gutters and prevent it following the wheel tracks, deepening them to ruts. Obtain the crown chiefly by rounding up the sub-grade or earth foundation, the remainder to be made up by the additional quantity of road metal placed in the centre of the roadway. Thus, for a roadway twenty-four feet wide, the crown of the sub grade should be nine inches, the remaining three inches to be secured by the difference in thickness of gravel between the centre and the sides. Care should be taken to make the crown perfectly circular.

FORMING THE ROADBED.

The practice in your town has been to pile gravel in the centre of the roadway on top of the natural soil, or to bring the earth from the gutters to the centre of the roadway, placing the gravel on top of this. This is the plan usually followed in grading township roads, but is totally unsuited to street construction.

The roadbed should be excavated to the required width to receive the gravel, broken stone or other material, and the excavated earth used in making boulevards or filling in the low lots to bring them to the grade of the street. The side of the street should be levelled to conform to the surface of the roadway. As far as practicable the crown of the finished street should not be higher than the adjoining property, but should conform to certain established grades.

ROLLING.

I do not understand how the town of Woodstock can expect to build roads without proper tools. In examining the outfit of roadmaking machinery, I found it to consist of wagons to haul gravel and shovels to spread it, and two small stone hammers. The wagons and shovels belong to the workmen. Roads cannot be built without tools.

For economical, durable and serviceable road-making, a heavy roller is indispensable. A road should be sufficiently smooth and compact to shed the water readily to the side gutters. If the gravel or other road metal is dropped from the wagon loosely on a soft earth foundation, as is your practice, water passes into the subsoil as through a sieve. Wheels passing over the road when in such a condition at once sink into and rut not only the gravel, but the earth beneath. Water is held in the ruts and each succeeding vehicle renders their condition worse. The road is less durable, since, the gravel being mixed with the dirt beneath, it obtains, when finally consolidated, a dusty, easily worn surface.

The weight of roller used must depend upon various circumstances—the amount of work it will be required to do, the quantity of road metal used, the strength of the bridges and culverts over which it must pass.

A steam roller costs much more than a horse roller, but does so much better and faster work that it is more economical. Municipalities surrounding your town would find it to their advantage to rent such a machine, thus keeping it employed, as it is too costly to remain idle. A weight of twelve tons does satisfactory work, and it is not too heavy for the majority of bridges.

Rolling should commence at the side of the road, approaching the centre gradually. If the roller is first passed over the centre the loose metal is crowded out and the shape of the road destroyed. It is best to roll the earth foundation in dry weather, and each succeeding layer up to the top dressing. When the latter is put on, the rolling should be continued in wet weather (or the metal thoroughly soaked from a hydrant or with an ordinary watering cart) until the metal is thoroughly compact and solid, able to resist, without displacement, the heaviest load passing over it.

ESTABLISHED GRADES.

Without a complete plan of fixed grades it is impossible to do perfect work, and as far as practicable when any work is undertaken it should embody the whole street, both roadway and sidewalk. The grade of the street should be so fixed as to utilize all excavated earth in making boulevards, bringing the sides of the streets up to the grade and filling in low-lying property so as to conform to such grade. Without this it is impossible to fix a grade other than that which will conform to the elevations of the lots. One piece of street about half a mile in length was pointed out to me on which the sidewalks were constructed in six different sections under six different by-laws within the last four years, and without any road improvement being attempted. The effect is that a

different grade has been given for each piece of walk, the best that could possibly be given under the circumstances, but by no means as good as could have been given if the work had been carried out as a whole. Also streets are improved and graded without reference to each other. The result is that the intersections are very uneven, and are not only inconvenient, but have an awkward and unfinished appearance.

Slopes should in all cases be reduced as far as practicable, having due regard to the proper draining of water in the gutters, and having regard to the elevation of the adjoining property, for in fixing this grade it is bad practice to injure such property by excessive cuts or fills in front of it to satisfy a uniform grade of the finished road.

CURBING.

On each side of the roadbed it is advisable to place a line of flagstone curbing four inches thick and two and one-half feet in depth. A good substitute on residence streets is three inch by ten inch cedar plank. It should be spiked to six inch in diameter cedar posts, two and one-half feet in length, which are placed at intervals of eight feet and bevelled at the top so that the curb will slope slightly towards the boulevard. This curbing defines the roadway, protects the boulevard and gutters, and keeps the road metal in place.

WIDTH OF PAVEMENT.

The usual width of your street allowance is sixty-six feet. This width is always advisable for sanitary reasons, besides adding greatly to the appearance of the street. It is, however, an unnecessary expense both in first cost and maintenance to have a wider driveway on residential streets than is necessary to accommodate the traffic. A broad carriage way is very beautiful, but so also are wide stretches of nicely sodded boulevard ornamented with handsome shade trees which are a notable feature of your town. Carriageways of from twenty to twenty-six feet are now being adopted on the residential streets of cities and are meeting with general approval.

HILLS.

The Dundas Street hill and the Mill Street hill are in very bad condition. A large quantity of gravel has been placed on them, but no attempt whatever has been made to prepare the foundation, or to provide gutters. The course of the water is now down the centre of the roadway, the finer particles of gravel have been washed out and, in consequence, the large stones are exposed, forming a rough surface, checked and lined with crevices. Hills need very careful treatment. No water should be allowed to pass over the hill by the roadside other than that which falls on or exudes from the hill itself. Water from above the hill should be carried in underdrains, through private property, if possible, to an outlet. Neglect of this results in dangerous and expensive washouts. Gutters on hills should be protected with cobble stones from rushes of water. Where water oozes from the side hills or from land lying higher than the surface of the road, this soakage water should be intercepted and conveyed to the tile drains. It is good practice to fill the trench over tile drains with broken stone, gravel or other porous material.

GRAVEL.

My attention was directed to the gravel in three pits, Rapson's, one on Joint Street, and another on the north side of the town. The material in the two former is of a very inferior quality in its natural state, being very largely mixed with sand, earthy matter and large boulders. In order to be of service in road construction, material of this kind should be screened to remove large stones, sand and earth. A means sometimes adopted is to place in the pit a stone crusher with screen attachment, whereby the refuse is removed; at the same time the large stones are broken and form a very valuable part of the road metal resulting.

The gravel in the pit on the north side of the town is excellent. Much of it is fit for application to the road without any treatment other than to remove occasional large stones.

Cleanliness of material is absolutely necessary. Sand and earth are very injurious to the roadway when mixed with gravel, as they attract and retain moisture and permit it to pass through to the sub-soil. A covering of this kind is not only less serviceable while it lasts, but is less durable than one composed of clean metal. Gravel should be placed on the road in layers of not more than four inches in depth, and each layer consolidated with a roller. The depth of gravel required on the street varies in proportion to the nature and extent of the traffic. On residential streets, little travelled, eight inches at the centre and five at the sides will be sufficient. Residential streets considerably travelled, with occasional heavy loads, will require nine inches in the centre and six inches at the sides. On other streets, largely travelled, ten inches in the centre and seven at the sides will be needed.

BROKEN STONE.

Broken stone is a much more durable material than gravel, providing, of course, that a suitable quality of stone is used. The best stone is that which is hard, tough and which will not readily decay on exposure to the atmosphere. The only stone to be had in the vicinity of Woodstock is field stone and river boulders. If these are crushed care should be taken to exclude rocks of a poor quality, the most common of which are "weathered" sandstones and granites. Some limestones also weather very rapidly. Slaty rocks are too brittle to be used on the road. There are heavily travelled streets in your town approaching the business centre which it would be well to pave with broken stone in place of gravel; and for preparing gravel and for breaking field stone, a stone crusher would be a very valuable machine for your town to possess.

The stone should be crushed and screened into sizes varying from one inch in diameter to two and one-half inches. The largest stone should be placed in the bottom of the roadbed and the smallest at the top. A road surface of a mixture of large and small stones, in time becomes very rough owing to the smaller wearing more rapidly than the larger, while large stones at the surface have a tendency to become loose.

The stone should be placed on the roadbed in layers and each layer thoroughly consolidated with a roller before the next is applied. The depth of the stone may vary, according to the traffic, from nine inches at the centre with six inches at the side, to twelve inches at the centre and nine inches at the side. As with gravel, it is very important that the material should be clean. No "binder" is needed with limestones. If an exceedingly hard metal such as trap is used, the fine "screenings" of the stone will be the best aid to consolidation. In rolling, the lower courses of stone should be perfectly dry, but in finishing the road, water may be used to flush a dressing of stone screenings into interstices.

GUTTERS.

When gravel or broken stone is used on business streets, the gutters should be cobblestoned similarly to those on Dundas street, which were evidently well laid; but on account of tearing up to make sewer and gas connections they have become somewhat injured. In opening the streets for this purpose, great care should be taken in replacing the earth and pavement. Pipe for sewer, gas and water connections should as far as possible be laid by drifting with an auger large enough to accommodate the pipe, excavations only large enough to perform this work being made. On residential streets, the angle between the curb and the road-surface usually forms a sufficient waterway for surface drainage.

VANSITTART AVE.

This avenue could be made one of the most magnificent residential streets in the province. It is 132 feet wide, the residences on each side are handsome, and the lawns surrounding them spacious, well-kept and tastefully designed. A very large amount of

money has been spent on the roadway, enough to have provided an asphalt pavement. Artificial stone sidewalks have been laid on each side of the street, boulevards made and neatly kept. But the dirty, imperfectly constructed and shapeless roadway is entirely out of keeping with its surroundings. While this street, on account of being a leading avenue, and on account of its exceptional width and beauty, attracted my attention specially, there are numerous other streets equally deserving of improvement.

SIDEWALKS.

Considerable attention has been given to the matter of sidewalks and they are now, generally speaking, in good condition. A large number of flag and artificial stone walks have been laid and add very much to the appearance of the town. The plan of laying the walks outside of the trees on residential streets has been largely followed, and is commendable. There should, however, be a narrow boulevard between the curb and the sidewalk, but, where there is not sufficient width of street allowance to permit of this, an exception should be made. If this boulevard does not exist between the sidewalk and the road, the beauty of the improvement is largely lost by giving the street a dry, dusty and business appearance, and frequently places the sidewalk so far from the trees as to be away from the shade. No sidewalk should be laid without a plan of the whole street being made, to show its location with respect to the roadway and other walks on the same street, in order to secure regular and uniform results.

SEWERS AND SEWER CONNECTIONS.

Where a sewer is necessary on a street it should be constructed before the improvement of the road is undertaken; and as far as practicable all sewer, water and gas connections should be laid to the street line in order to prevent the breaking up of the roadway for this purpose. A macadam road cannot be broken up with injury, and the damage to a brick or asphalt pavement is correspondingly great. I would advise that special attention be given to this matter before Dundas street is repaved.

DUNDAS STREET.

The life of the cedar block pavement on Dundas street is about expired, the material is decayed, has become uneven and rough, and must in a very short time be renewed; but although in this condition, it will, I presume, be used for another year, during which time your council should carefully consider the merits of the different pavements. Neither gravel nor macadam make a suitable pavement for the business thoroughfares of a town of the size of Woodstock. The pavement on Dundas street, in the business portions, should be surfaced with a much more durable material than either of these, a material which will be easily kept clean, so that it may be crossed at any point, will be sanitary, and will in every way give good service. A dirty, muddy, rough main street is certainly a poor advertisement for a town.

The qualities essential to a first-class pavement are:

- (1) A secure and pleasant footing for horses.
- (2) Smooth, so as to render travelling and traction agreeable, easy and noiseless.
- (3) It should be sanitary; the form and material such that it will be impervious, liquids will not have permanent lodgement, and dust will not be easily produced.
- (4) The durability and service rendered will be commensurate with the cost of construction and maintenance; that is, it must be economical.
- (5) It must be easy of removal, replacement and repair and at reasonable cost, and with the appliances and materials within the control of the corporation.

In view of the above it will be apparent, I believe, that brick and asphalt are the two competing materials for use on Dundas street. With regard to the first quality, the

foothold afforded to horses, bricks must have the preference. It is one of the objectionable features of asphalt that it is exceedingly slippery when wet, and even when dry it is not always safe.

As to the second quality, asphalt must take first place since it is in a slight degree smoother and less noiseless than brick. It is doubtful, however, if traction is any easier, owing to the insecure footing afforded to horses.

There is little if any difference between the sanitary status of the two pavements. Both are, of course, impermeable and offer little resistance to the flow of liquids; the joints of the brick are just sufficient to retain moisture and subdue dust. With the smooth asphalt surface no amount of sprinkling will keep the surface moist in hot weather.

As to cost, asphalt is from one-half to one-third more than brick, and experience has not proven its life to be any greater. As to durability, there must always be the proviso, that good material and proper plans and methods of construction are used in any case.

The laying or repairing of brick does not require skilled labor as does asphalt, and this difficulty in connection with the latter is felt more particularly in places where only a short section of asphalt is used. In large cities the inconvenience is not so great.

While asphalt is extensively used in the United States and Canada, and is unquestionably a good paving material for certain streets of large cities, I believe brick more suited to the requirements of your town.

The quality of a brick pavement is not to be gauged by the best brick used in its construction, but by the poorest. For this reason it is necessary, before deciding on the kind to use, to see that it comes up to the standard of scientific tests. More than this, while the building of the pavement is in progress there should be careful inspection to see that no brick of an inferior quality is used.

There is a tendency also, to endeavor to reduce the cost of a pavement by having a cheap foundation. Foundations of gravel, sand, and macadam have proven successful in a number of cases, but only where the natural sub soil is of a loose and porous nature. In this climate, where we are subjected to alternatives of frost and slush, the experiment is a dangerous one. A foundation of four inches of concrete should be used. On this, place a one-inch cushion of sand and fill the joints of the brick with a cement of tar or pitch and sand. The earth sub-soil should, of course, have been previously graded, and consolidated with a heavy roller.

TIRES.

To consider the cost of the construction of pavements is important, but the cost of their maintenance is not to be overlooked; and this latter will necessarily be very great so long as the use of narrow tires is permitted. The cost of maintenance falls on the same individuals as does the cost of construction, and as the users of vehicles are members of the community, it is hard to understand why they should wish to tax themselves for the additional cost of maintenance, and the additional cost of transportation caused by bad roads, the result of narrow tires. The use of narrow tires delays the era of good roads to a greater extent than does any other cause. The roads of European countries owe their perfection very largely to the tires which are sometimes as broad as ten inches, the tire of the ordinary market wagon being six inches in width. No town should be without a by-law regulating the width of tires, and no drays used for delivering heavy loads from the depots should have tires of less width than eight inches. Various towns in the province are now taking steps to regulate this matter.

PUBLIC WORKS.

Very rarely does the average citizen consider the meaning of a municipal corporation. It is merely a society organized to carry on certain institutions in a more serviceable and economical manner that would be possible for the individual member. The

character therefore of a town's public works are an index to the good judgment and taste of the citizens as a body. The handsome lawns and well kept private properties so numerous in Woodstock are indicative of the aspirations of the citizens toward rendering the town as perfect a place of residence as it can be made, and point to the conclusion that they are willing and prepared to bear their respective portions of the cost, as soon as they find that progress at a reasonable cost can be made. Every improvement made in a town helps to build up the town, and is in this respect a benefit to every ratepayer. While sewers and waterworks are necessary to a town's welfare on sanitary grounds, the proper construction and maintenance, at the same time beautifying the public thoroughfares, is a matter which you cannot in the future, as in the past, afford to overlook.

I was very much pleased with the active interest taken in the question by your council, and their evident desire to place this important part of municipal affairs on a business-like basis. The interest exhibited also at the public meetings of the citizens is an evidence that they have been considering the matter and are awake to the inefficiency of present methods.

TOWNSHIP REPORT.

To the Reeves and Councils of the Townships of East Nissouri, West Zorra and East Zorra :

GENTLEMEN : In accordance with your invitation, I visited your townships, drove over the roads, inspected their present condition, examined the material available for road construction, the system of expenditure, the methods and plans used in doing road work, the administration of the statute labor law, and beg to submit the following report and recommendations :

LABOR AND ROAD EXPENDITURE.

The roads of your townships are built and maintained under the statute labor system, supplemented by grants from the municipal funds. The statute labor system has some commendable features. Under it good work can be done, and has been done, at less cost to the taxpayer than could perhaps have been obtained otherwise. It is, however, peculiarly subject to neglect and evasion, and this has been taken advantage of to such an extent that the roads of your district have suffered in consequence. The manner in which road work is slighted is too well known to need description. The wagons, horses and implements often brought out for use on the road, make up an assortment that would disgust any intelligent farmer, if he had to pay for them by the day at one-quarter rates for work on his farm. The work is too frequently done in a spiritless way, and a great part of the time is spent in talk. Some townships in various parts of the province commute the statute labor at such a reduced rate as to be practically an acknowledgement that statute labor has been shamefully neglected and thus brought into disrepute. The experience of one municipality is that, commuting at thirty-five cents per day, better results are obtained. That such could be the case is certainly a reflection on any municipality, and rather than commute at so low or even at a reduced rate, it is worth a struggle on the part of a township to make each day of statute labor worth one dollar in actual results on the roads.

Were the statute labor system economically administered, it would take only a short time to work a complete transformation in the condition of your roads. The true spirit in which statute labor should be performed was exhibited in the work of the pioneers, in road-making. In their day, population was sparse and the road allowance had to be cleared of forest. Stumps had to be grubbed, bogs burned, the roadway graded, swamps corduroyed, and streams bridged. Drainage was exceedingly difficult and there was no municipal fund from which to draw, for mending a culvert or filling in ruts. Labor was

then concentrated, and good, honest labor was given. Now, however, with the increase of population and wealth, roadwork is scattered in patch-work, and is done in a half-hearted way.

Statute labor is performed at a period of the year when the time of every farmer is of great value to him on his own farm. If the work of improving the roads is neglected, and a portion of the time spent in statute labor is wasted, it must be apparent to every citizen of the Province that there is a tremendous amount of energy lost to the country. We are obtaining our roads at an enormous expense, and if they are still to be bad roads, the expense is many times increased indirectly. Sufficient money is now being expended in your townships for material, if it were carefully prepared and skilfully applied.

NUMBER OF PATHMASTERS.

In order to bring the roads to proper condition, the operation of the statute labor system in your municipalities must be placed on a more systematic basis. One of the first steps would be to reduce the number of pathmasters. In each of your townships there are about 100 pathmasters, and, in consequence, as many different ideas of road building. The result, as shown on the ground, is that one pathmaster has considered sixteen feet a sufficient width of roadway, another eighteen, another twenty, and so on up to forty feet; one thinks a roadway should be flat; another that it should be rounded up a few inches; another, a few feet. Instances of these differences of opinion might be multiplied to almost any extent. Certainly all cannot be right, and this points to the fact that the control of the roads should be concentrated in fewer pathmasters under one central head. One man should have general oversight of the pathmasters and all work and expenditure on roads and bridges; and he should be required to report to the council at each meeting. He should have charge of all township machinery and materials. He should be a man specially adapted to the work, and his tenure of office should be as secure as that of the clerk or treasurer.

Besides being encumbered by the number of pathmasters, none of whom have sufficient means at their disposal to do permanent work, each pathmaster is surrounded by a few neighbors, and rather than incur disfavor by insisting on a fair day's work, frequently invites popularity by allowing or even encouraging neglect of the work. Were the beats enlarged, every pathmaster would become more independent and would have a sufficient number of days of labor under his control to undertake durable and complete work. But with their knowledge and experience in road making, it cannot be in the interest of the townships for each pathmaster to be given the power to carry out his own ideas and experience on the road. To believe that every man is a born road-maker is a great mistake, and in order to get over the evil it is necessary that every citizen should be willing to join hands with his neighbor, and to work under a man specially instructed. The work cannot be planned nor carried out to suit everybody. An army composed entirely of commanding officers, or a party of workmen made up of foremen, cannot make much headway.

PATHMASTERS.

Pathmasters should be chosen from among the most respected, intelligent men in the community, and they should be kept in office. Even then, their individual opinions and plans should be subject to revision by the council, which body should exercise a direct oversight of the roads, and their improvement by statute labor.

That there are men who could fill the office of pathmaster in a creditable manner, is apparent from the fact that, in driving over your roads, there were several sections which have been well done, and good pieces of road constructed by statute labor alone. That many are poor pathmasters is indicated by other sections which show no evidence of results except those produced by the expenditure of municipal taxes, contributed very largely by those who had worked with a will in performing their own statute labor on other beats.

When men of suitable ability, knowledge and experience have been once obtained, they should be retained in office. By the present system of annual rotation, as soon as the pathmaster has learned something in his year of apprenticeship, his experience is lost and another is appointed, who begins in his turn to take lessons in road-making at the expense of their condition. In other occupations an apprenticeship of some years is necessary before a person is qualified to practice, but a pathmaster, the moment he is chosen, is thought fit to direct a work requiring much science, at the expense of the township's capital of time, labor and money. Men are taken from the occupation in which they are skilled, and are transferred to one of which they know nothing. An honest man knows this, and immediately strives, from his personal experience, from the advice of others trained by practice and instruction, from experts, and from every available source, to properly qualify himself; with this and with continued experience he can become a most valuable officer. Such a man realizes the responsibility of his position and the duty he owes his fellow citizens whose property is placed in his charge, the expenditure of whose money he directs, and whose interests he is expected to advance. He commands the respect of those who have to serve under him, his order is obeyed, public interest is created and maintained, and the question of making good roads is rendered simple, requiring but a small outlay of money.

There is another man who strives for the office of pathmaster, and looks upon his appointment merely as a victory over a neighbor. He exercises his authority in performing some act to aggravate a citizen with whom he does not see eye to eye. The improvement of the road is by no means the prime object; injury rather than betterment is the probable result, and those who are obliged to perform the work become disgusted.

Some men look upon their appointment as an acknowledgement by the council and community of their special skill as road-makers. The solicitation or acceptance of any advice from experienced men would be looked upon as a confession of unfitness, and certainly any suggestion to accept instruction from an expert would be regarded with contempt. The competent pathmaster, as well as the competent business man, is he who eagerly seeks, from every source, the fullest possible information pertaining to his special line, believing that his knowledge never can be too perfect.

LOYALTY TO PATHMASTERS.

It is one of the weaknesses of the statute labor system, that it is very difficult for a pathmaster to enforce prompt obedience to his orders. If a neighbor persists in idleness, or if, instead of doing as he is directed, he stops and argues for an hour on the wisdom of so doing, the pathmaster cannot obtain redress except at the expense of his neighbor's good-will, a step very few pathmasters are willing to take. A farmer could and would discharge an employee for pursuing such a course, but in the case of a pathmaster the roads must suffer. Under a proper administration of the statute labor law, it is apparent that it is the duty of every man, when performing statute labor, to set aside his personal feelings and opinions, and promptly do the work allotted him. This is the relation of the tax-payer to the pathmaster. On the other hand, the pathmaster (and going further back, the council), owes it to the tax-payer that all plans shall be carefully prepared and considered before the work is commenced, so that improvement will be made along the right line, and with the greatest economy of labor.

GRAVEL.

There appears to be a desire on the part of the people of your townships to put in their time by drawing gravel; and gravel is therefore hauled and dumped on the roads before the foundations has been prepared to receive it. I learned that, in West Zorra, \$600 was paid this year for gravel (that is, just for the material), but most of the stuff placed on the roads is almost worthless, although first-class gravel is to be found in various pits in each township. Judging from the immense excavations, many thousands

of loads have been drawn, and farms have been paid for with the amount received for the gravel taken from one small corner. Contrasting the amount of material placed on the roads, with their condition as a whole, it is evident that there has been great waste.

Buying gravel by the load is like buying water by the bucket. Borings and test-pits should be sunk where gravel is known to exist, and the amount estimated from these borings. The material should be purchased in a business-like way for a fair amount; and in case of opposition from the owner, the land may be expropriated if necessary.

One source of the use of poor and dirty gravel arises from insufficient care in taking it from the pit. The social feature of statute labor is carried to the extent that those drawing gravel want to load up together, drive together to the place of dumping and return in company to the pit. There may be a dozen teams, and only room for one or two where good material is to be had in the pit. The remaining ten, however, drive in and fill up the wagon boxes with anything in sight, whether sand, clay or boulders, and this is the kind of "gravel" with which a good many roads are surfaced.

Not only should gravel be chosen from the best part of the pit, but care should be taken to sort out any bad stuff, sand, boulders, etc., that may be mixed with this. Gravel pits are covered usually with a deep layer of clay, loam or earthy material, useless on a road. While this is not shovelled directly into the wagons, it is undermined, falls down on the good gravel, and then goes along with it to the road.

CLAY AND SAND IN GRAVEL.

Dirt mixed with gravel is not only useless, but is hurtful to the road. Evidence of this is found on your roads where a few loads of clean, hard gravel, have been placed on the road, followed by a load or two of dirty stuff, then clean metal, then dirty, and so on. The surface of such a road is a series of ups and downs, some smooth spots, then ruts.

It is contended that a certain amount of clay and sand is needed to act as a binder, and sections of roadway are pointed out which have consolidated readily, and make a nice smooth drive. This is undoubtedly the case during summer, but it will be found that a pleasant summer road is frequently a very poor fall and spring road. The bond made by sand and clay is weak, and there is not the mechanical hold which one stone takes upon another by pressure, as is the case when clean material is used and well rolled. The result is that an extended rain turns the road into slush, mud and ruts.

When clay or sand is mixed with gravel, it absorbs and retains moisture, the whole yielding readily under traffic. It has not the power to support wheels that good clean material has. In a number of townships throughout the Province, the practice of screening the gravel is successfully followed.

STONE CRUSHERS.

Where such a large amount of money is spent annually for gravel, which, when laid on the road in its natural condition is largely useless, it appears to me that one of the first considerations of your council should be the purchase of a crusher whereby the gravel might be properly prepared, and nothing hauled but first-class material. By placing a crusher in the pit, all material could be passed through, and with a rotary screen attached, all sand, clay and fine stuff would be removed, leaving only the clean road metal. In some sections of your townships, field stone is plentiful, and gravel has to be hauled several miles. Where such is the case, the field stone might be crushed and placed on the roadway, making a more durable road at less cost than gravel. The work of crushing could be done at any suitable season of the year, in the pit or field, and the material left in piles ready to be placed on the road whenever needed.

DRAINAGE.

The drainage of a road is quite as important as the gravelling, but the best way to obtain this must be one adapted to the nature and elevation of the soil, and the direction and extent of natural watercourses, etc. It is imperative, however, that provision shall be made wherever the soil is in a low or wet location, or is of a retentive nature, that it shall be drained both above the surface and below it. Sandy or gravelly soils very frequently do not need sub-drainage, while clay always requires it. Unless there is natural sub-drainage, artificial underdrainage must be resorted to.

Considerable has been done in making open drains by the roadsides in your townships, but a great many of these need deepening and cleaning to provide better sub-drainage. A much better practice than having deep open drains, is to use tile placed below frost line. These should, wherever practicable, be placed beneath the present open drains on each side of the road. No matter how good the material placed on the surface of the roadway, unless the natural soil beneath is kept dry the metal is forced down and the mud comes to the surface. When roads in this country are gravelled, they are frequently termed "Macadam." The important feature of the roads built by Macadam, however, was the drainage, not the surface covering.

Tile and open drains must be kept free, with a good fall to an unobstructed outlet. It is useless to drain water from the roadway and then keep it standing in drains until it soaks into and softens the natural soil under the gravel. At all seasons of the year, particularly spring and fall, when obstructions of snow and ice are likely to occur, the outlets should receive special attention.

CROWNING THE ROAD.

Too much crowning is as bad as too little; but the road must be crowned or rounded to shed the water to side gutters. A great many of your gravelled roads are perfectly flat, and some are lower at the centre than at the side. To provide for wear and settling, the roads, when in a proper state of repair, have a rise of about one inch to the foot from the side to the centre. To crown the existing gravel roads which are too flat, the square shoulders at the side should be cut off. If these shoulders are composed of clean gravel, forced from the centre of the road by the wheels, the material may be drawn in towards the centre. As a rule, however, it is of such a quality as will turn to mud immediately the fall rains commence, and should be used in levelling the sides of the road, or in any other way that circumstances may make advisable. This stuff from the shoulders of the road has, in some instances, been brought indiscriminately to the crown of the road, with the result that a firm gravel foundation has received a coating of mud. During the summer it may have made a very pleasant surface, but in wet weather it becomes slushy, holds water and destroys the foundation beneath it. The shoulders having been disposed of, clean material from the pit should be placed in the centre. It will frequently be found that a sufficient depth of gravel is already on the road, requiring only the cutting off of the sides, and shaping up with a light coating of clean material properly applied. To do this work perfectly, quickly and economically, road graders should be used.

APPLYING GRAVEL TO THE ROADWAY.

The gravel placed on the roads of your townships has been merely dumped in the centre without any further treatment. The first effect of this is to drive vehicles to the side of the road. These side tracks are used until late in the fall when they have become cut up and flattened to such an extent as to destroy the shape of the road, preventing surface drainage. Water is held at the side, soaks into the roadway, and the gravel is forced down into the mud and is largely wasted.

Gravel should be nicely spread on the roadway and thoroughly rolled so that travel will at once use it. The objection is made to the use of clean gravel that it will not con-

solidate, a difficulty entirely removed by the use of a roller. If a roller is not used, the gravel should be raked into the wheel tracks and into the hollow worn by single horses, until the whole roadway is hard and smooth under traffic.

WIDTH OF ROADWAY.

The width of driveway on the majority of the roads in your townships has already been fixed by sharp, open ditches, and where the road has been coated with gravel, it will usually be found impracticable to alter it now. A gravelled strip, however, of eight feet in the centre is sufficient to accommodate the traffic on the greater number of your roads, and a greater width than twenty-four feet between ditches will generally be found needlessly expensive to maintain. If the roads of your townships were properly under-drained so that the open drains could be very shallow, a less width than twenty-four feet would generally be not only cheaper but better. A less width than eighteen feet is rarely advisable.

ROAD GRADERS.

Road graders are as necessary on the road as are self-binders in the harvest field, and if true economy is to be considered, are absolutely indispensable. When properly managed, a grader will do the work of from fifty to seventy-five men in shaping, crowning and scraping a road. One capable man should be employed to operate it whenever it is in use, as it requires considerable experience to handle it to the best advantage. The operator should know something about roads, and should be capable of following minutely instructions received from the Council. A grading machine of itself has no knowledge of road-making, and unless the operator has, satisfactory results cannot be obtained. By using such an implement for a few days on each statute labor beat, it is apparent that very much could be accomplished in shaping up the edges of existing gravel roads, and in grading dirt roads which have had but little attention.

LOCATION OF ROADS.

As the sustaining power of a chain is no greater than the strength of its weakest link, so the utility of a road is measured largely by the steepest grade or poorest section. For this reason, hills, cuts and steep grades should be avoided, and the best ground for a road foundation should be chosen. Such pieces of road as are on hills should be judiciously altered to obtain easy grades, provision being made in the Municipal Act for such changes of location. A mistake sometimes arises from the idea that the distance over a hill is necessarily shorter than the distance round it; and that the distance down the valley and up, is shorter than the detour necessary to avoid it; whereas the reverse may be the case; and in any event, the steep grades, necessitating smaller loads, loss of time and expense for maintenance, form a very great consideration.

This is a very important matter which should be considered as far as possible at once. The longer the delay, the more difficult it will become to rectify errors. Numerous instances will be found throughout your townships in which a slight change in the course of a road would result not only in a great saving in building and maintaining it, but would add to the convenience of traffic.

HILLS.

Hills need very careful treatment. Water is very commonly carried long distances by the side of the road, past natural water courses and through deep cuts in order to dispose of it over a hill. The secret of successful drainage is to dispose of water in small quantities, without allowing it to gain force and headway. Neglect of this principle is the cause of the bad condition of so many hills, making deep washouts and necessitating expensive repairs.

Hills are frequently springy, or are kept soft by water oozing from them. In such cases a line of common farm tile should be placed on each side of the roadway, underneath the gutter, and below frost. Wet points should always be tapped by blind drains leading diagonally across the roadway to side under-drains. The crown of the roadway on hills should be sharper than on level ground, otherwise water will follow the wheel tracks, deepening them to ruts, instead of being shed to the side gutters.

BRIDGES AND CULVERTS.

The repairing and renewing of wooden bridges, sluiceways and culverts is a constant drain on the funds of a municipality. Timber is becoming expensive and iron is each year decreasing in price. It is encouraging to find your councils studying true economy in the construction of bridges by the use of stone and iron. The first cost of such permanent structures is much greater than that of wood, but with the greater term of duration and the fewer repairs needed, they will in the end be found less costly than wood, at the same time giving better service.

Cement culverts are used largely, particularly in East Nissouri, and will be found much more economical and more serviceable than wood. When properly constructed, with a free outlet, they are permanent, and in a few years your councils will be largely relieved of expenditure from this source.

TIRES.

People tax themselves in time, labor and money for constructing roads, and then purchase narrow tired wagons to destroy them. If tires of from four to six inches were used on lumber wagons in your townships, a very great change would be quickly noticed in the condition of the roads. The difference between a narrow tire and a wide tire on a road, is about the same as the difference between a pick and a pounder. The one tears up, the other consolidates. When wide tires come into general use, a great part of the question of good roads will be solved, as the wear of the road is nearly as important an item to consider as its construction. With wide tires, the cost of keeping roads gravelled would be reduced one-half.

It is objected to broad tires that they are heavy to draw over a rutted or stoney road. It is, however, the narrow tires which are so largely responsible for the ruts and for working the stones loose; instead of which, wide tires would keep the roadbed smooth and would compress stones into it.

MAINTENANCE OF ROADS.

The roads of your townships receive very little attention except at the time of performing statute labor. Roads are very much more cheaply and easily kept in good condition if repairs are made as soon as wear appears, for ruts and wheel tracks interfere with surface drainage, hold the water, and quickly cause the road to "break up" in wet weather. Repairs of this kind are of such a simple nature, requiring a little raking, filling a rut, the freeing of an obstructed drain, at the most a load of gravel, that every farmer could, with no loss of time, see that the half of the road allowance passing his farm was not neglected in such trifling matters. Attention of this kind would result in an immense benefit to every resident of the townships.

Instead, however, of men having sufficient public spirit to volunteer work of this description, we find them adopting all sorts of means to avoid doing even their just amount of statute labor. These men, after idling away their time, will wait in deputations on the councils, complaining of the bad and dangerous condition of their roads, asking for municipal grants to do the work which they should, in justice to other taxpayers, have done by their statute labor. No encouragement should be given in such cases by making money grants where the ratepayers neglect to make good use of their statute labor.

An excellent system has been adopted in some townships which has been productive of good results. Under a by-law of the municipality, where any section subscribes an amount of money for road improvement, the municipal council assists with an equal amount from the general funds. In other townships, no money is paid out for gravel unless the road division has first drained, graded and formed the roadway according to the set specifications of the municipal council.

If, however, a section of the people persist in looking on their statute labor as a joke, if the present waste and injustice continues, and the roads are permitted to remain in an unsatisfactory condition, a hindrance to individual and national progress; if, after a fair trial, it is found that the statute labor law cannot be operated in your townships on business principles, it will be the inevitable result that your ratepayers will demand its abolition and the substitution of a law that will be less easy to evade. This has been the result in numerous other townships, and if the old system is to exist still in your townships, its friends must make a radical change in the present methods of administration and prove its worth.

TOLL ROADS.

In a long settled and wealthy community such as Oxford, it is usual to find the main roads in fairly good condition. I was quite surprised to find, however, that this is rarely the case in your townships, and more so when I was informed that a number of these roads, especially near the business centres, are in the hands of chartered companies. The people have been taxed directly and heavily for these roads for nearly half a century. They were nevertheless in a deplorable state at the time of my visit.

The user of the toll-road is supposed to be taxed for travelling on a good road, not a bad one, and if there is any reason for these roads being in the hands of private corporations, it is that the public shall be benefitted. These roads on which heavy toll has been collected for so many years, in a populous and wealthy community, should be models for the construction of roads under municipal control. The only features which seemed to distinguish them from some of your concession roads were the toll gates at frequent intervals.

It may be urged by the owners of these toll roads, that a fair proportion of the earnings is being spent on them to place them in good condition, but if so, those in charge of this expenditure should also take lessons in road-making. The paying of toll is a system of taxation both antiquated and annoying, and becomes especially so when the roads are badly maintained.

GOOD ROADS.

There is a tendency on the part of some to look upon the good roads agitation as a stupendous enterprise, and to wonder how "they" can ever make all the roads of Ontario. In order to bring the roads of the entire Province to a good condition, no pathmaster and his men would have to go beyond their own beat.

In some divisions under incompetent pathmasters, men rake and scrape the mud, and idle away their time, expecting to receive grants from the council to do their work. When good roads are mentioned, they sit down on the bank of the ditch and ask what they will cost, and where the money will come from, wasting additional time in arguing against the movement. If those who built up the pioneer settlements, who chopped trees, grubbed the stumps, logged, burned and cleared the allowance, graded the roads, corduroyed the swamps, and bridged the streams by their united, zealous toil, without the aid of municipal grants, if these had sat down and estimated the cost, and cried for money, we would to-day have no roads, and your townships would still be a wilderness. Surely, with allowances cleared, the larger amount of grading done, material plentiful, increased population, knowledge and ability, and large amounts appropriated annually for road improvement, it cannot be a question of money.

A reorganization of the statute labor system bringing it to a business-like basis, gravel taken from the pit and applied more carefully, a better acquaintance with the principles of road-making, better drainage, proper implements, wider tires, a personal interest on the part of every citizen in keeping roads in a proper state of repair—these are the reforms necessary to improve your roads economically, durably and efficiently. These constitute the true objects of the good roads movement.

It would scarcely seem necessary to urge upon the residents of the rich and long settled townships of Oxford (a county which for many years has claimed the distinction of being a most progressive district, the garden of the Dominion), the benefits to be derived from, and the great need of better roads. While the county is a model one in many respects, in its handsome farm residences, its splendid barns, its reputation for high-grade stock, the roads nevertheless, are far from being such as I could recommend to other municipalities as models. That a community which thoroughly comprehends the advantages to be derived from modern improvements in agriculture, should be so far behind in matters pertaining to road improvement, is certainly to be regretted. But with a live interest now being taken by the citizens generally, in this branch of public improvement, I believe your councils will find the task of reform a comparatively easy one.

CEMENT-CONCRETE SIDEWALKS.

In connection with the improvement of streets, there is a widespread tendency to replace wooden sidewalks with others of more permanent material. In fixing grades, it will generally be necessary to undertake the construction of the entire street—roadway, sidewalks, boulevards—if the best results are to be attained, and for the purpose of economically and easily handling the excavated earth. Wooden sidewalks are lacking in durability, need constant attention to keep them in a safe condition, are not agreeable to walk on when a little worn, and will, in their ultimate cost, be found more costly than those of cement-concrete.

In constructing this latter class of walk, the space over which it is to be laid should be excavated to a depth of twelve inches below the top of the proposed walk, perishable or objectionable material being removed to a greater depth if necessary. The bottom of the excavation is then compacted by pounding or rolling until as firm as possible.

On the bed so prepared a layer of clean gravel or broken stone is spread to such a depth as will give, on thorough consolidation, a thickness of seven inches. Temporary curbs of pine should be set on each side of the excavation, to be removed after the walk has hardened.

On this foundation, and in the mold formed by the curbs, is placed four inches of concrete which should be composed of small broken stone, of a size not greater than one and a quarter inches in any direction, and entirely free from dirt or dust; clean screened gravel, sharp sand and Portland cement. This should be thoroughly rammed, and may be of the following proportions:

Cement	1 part
Broken stone	5 parts
Clean gravel	2½ parts

Slab or flag divisions are then marked off, from sixteen to twenty feet in length. This provides for settlement, expansion and contraction from frost, and lessens the tendency of the walk to crack irregularly from these causes. The joints should be filled with sand or other approved separating material.

Before the concrete has set, and while it is still adhesive, there should be laid on it a wearing surface one inch in thickness. This surface coating may be composed, if a sand finish is desired, of:

Portland cement	2 parts
Sharp sand	3 "

Over this should be sifted a layer of the best Portland cement, the whole to be then levelled, neatly trowelled, and rolled with a tooth roller to make a surface which will not be slippery. A more durable surface coating, known as granolithic, may be had by using broken granite in place of the sand. This broken stone should have a square or cubical fracture, be clean and fresh, and of sizes three-eighths of an inch downward. The composition will then be :

Portland cement	2 parts
Broken granite	3 "

The work should be kept moist, and protected from the direct rays of the sun, with canvas, until thoroughly set. Traffic should be kept off for a period of about fifteen days.

The various parts, cement, sand and broken stone, should be measured and mixed when dry, water then added as required, and the whole again thoroughly manipulated and mixed. There is a great necessity for careful and skilled workmanship, and an experienced man should have charge of the work.

If the sub-soil is of a nature to retain water, is low-lying and not sufficiently under-drained, a line of common field tile should first be placed below the centre of the walk. The surface of the finished walk should have a slope towards the gutter of one-quarter of an inch to each foot of width.

When built by a contractor, he should be required to guarantee that the walk shall last and remain in all respects in perfect order and condition, and free from all cracks and defects, and of perfect hardness consistency, smoothness and finish, for at least the term of five years from the date of its completion, unless subjected to other influence than the ordinary effects of wear and weather.

STATUTE LABOR LAW IN TOWNSHIPS.

The main provisions of the statute labor laws are the following ;

(1) Every male inhabitant of the age of twenty-one years and upwards, and under sixty years, who is not otherwise assessed, and who is not in her Majesty's Military or Naval Service, on full pay or actual service, is liable to one day of statute labor on the roads and highways.

(2) Every person assessed upon the assessment roll of a township shall, if his property is assessed at not more than \$300, be liable to two days statute labor ; at more than \$300, but not more than \$500, three days ; at more than \$500, but not more than \$700, four days ; at more than \$700, and not more than \$900, five days ; and for every \$300 over \$900, or any fractional part thereof over \$150, one additional day.

(3) In townships where farm lots have been subdivided into park or village lots, and the owners are not resident, and have not required their names to be entered on the assessment roll, the statute labor shall be commuted, where such lots are under the value of \$200, to a rate not exceeding one-half per centum on the valuation, but the council may direct a less rate to be imposed by a general by-law affecting such lots.

(4) A farmer's son rated and entered as such on the assessment roll is liable to perform statute labor as if he were not so assessed ; but a tenant farmer's son, bona fide resident on the farm of his father or mother, is exempt from statute labor in the same manner as if he were the son of an owner and jointly assessed.

(5) A non-resident, wishing to perform his statute labor, must require his name to be entered on the roll, otherwise a commutation tax is charged against his property according to the assessed value.

(6) Where a resident owner, tenant, or occupant, who has caused his name to be entered upon the assessment roll, after notice or demand, makes default in performing his statute labor or in payment of commutation for the same, the overseer of the highways in whose division he is placed shall return him as a defaulter to the clerk of the

municipality before the fifteenth day of August, and the clerk shall, in that case, enter the commutation for statute labor against his name in the collector's roll, and the same shall be collected by the collector.

(7) In every case the clerk shall notify the overseer of highways, that may be appointed for such division, in the following year, of the amount of such commutation, and the overseer shall expend the amount of such commutation upon the roads in the statute labor division where the property is situate, and shall give an order upon the treasurer of the municipality to the person performing the work.

BY-LAWS.

The council of every township may pass by-laws.

(1) For empowering any person, resident or non-resident, liable to statute labor within the municipality to compound for such labor, for any term not exceeding five years, at any sum not exceeding \$1 for each day's labor ;

(2) For providing that a sum of money, not exceeding \$1 for each day's labor, may or shall be paid in commutation of such statute labor ;

(3) For increasing or reducing the number of days labor, to which the persons rated on the assessment roll shall be liable, in proportion to the statute labor to which such persons are liable, in respect of the amounts at which they are assessed, or otherwise, respectively ;

(4) For enforcing the performance of statute labor, or payment of a commutation in money in lieu thereof, when not otherwise provided by law ;

(5) For regulating the manner and the divisions in which statute labor or commutation money shall be performed or expended ;

(6) For reducing the amount of statute labor to be performed by the ratepayers or others within the municipality, or for entirely abolishing such statute labor ;

(7) For reducing or varying the amount of statute labor to be performed by the ratepayers or others within certain defined areas in the municipality when, in the opinion of the council, exceptional circumstances exist, rendering such reduction or variation equitable, and upon such conditions as may be imposed by the by-law ;

(8) For providing for the making and keeping open of township roads during the season of sleighing in each year, and for appointing overseers of highways, or pathmasters to perform that duty, and such overseers and pathmasters shall have full power to call out persons liable to perform statute labor within their respective municipalities to assist in keeping open such roads, and may give to such persons as may be employed in so doing certificates of having performed statute labor to the amount of the day's work done, and such work shall be allowed for to such persons in their next season's statute labor.

(9) For providing for the application of so much of the commutation of the statute labor fund, as may be necessary for keeping open such roads as last aforesaid, within such respective municipalities.

(10) For providing that the pathmasters in their several road divisions, or other officers appointed for the purpose, shall enforce the provisions of by-laws respecting obstructions placed on the roads.

(11) For appointing overseers of highways, road surveyors, road commissioners, or other officers required by the corporation ; and for regulating the remuneration, and duties of such officers.

The foregoing provisions will be found in the Consolidated Assessment Act of 1892, sections 87 to 101 ; the Consolidated Municipal Act of 1892, sections 479 and 521 ; the Municipal Amendment Acts of 1894 and 1895.

534.—When a county council assumes by by-law, any road or bridge within a township as a county road or bridge, the council shall, with as little delay as reasonably may be, and at the expense of the county, cause the road to be planked, gravelled or macadamized, or the bridge to be built in a good and substantial manner; and further, the county council shall cause to be built and maintained in like manner, all bridges on any river or stream over 100 feet in width, within the limits of any incorporated village in the county, necessary to connect any main public highway leading through the county.

SIDEWALK CONSTRUCTION IN TOWNS.

57 V. chap. 50, sec. 16.—It shall be lawful for the council of the corporation of any city or town which has not adopted the local improvement system in respect of sidewalks, by by-law to provide from the general funds of the municipality, or to raise by way of loan on the credit of the debentures of the municipality, forty per cent. of that part of the construction of granolithic, stone, asphalt, or brick sidewalks upon leading or principal business streets of such city or town as local improvements falling on the property benefited, in addition to the part of such cost to be provided by the municipality, and to add said forty per cent. to the said part of the cost of the construction of the said sidewalks to be provided by the municipality, and to issue debentures for the amount thus obtained, and it shall not be necessary to submit the by-laws of the said corporation authorizing the issuing of the said debentures to, or to have the assent of, the electors of the municipality before the final passing thereof, but any by-law for carrying the provisions of this section into effect, both as to selecting streets and providing the necessary funds, shall require an affirmative vote of three-fourths of the members of the council.

(1)—The remainder of that part of the cost of constructing the said sidewalks, falling on the property benefited, after the said forty per cent. has been deducted, shall be assessed for and dealt with in the manner provided as to assessments for local improvements in other cases.



THE RESULT OF RIGHT PRINCIPLES.

Increased property values, and, in ultimate cost, a measure of economy and decreased taxation.



MONEY SCATTERED AND MISAPPLIED.

Few back townships have worse roads than the average town.



A ROCK-CRUSHER NEEDED.
Stone for fences but none for roads.



THE COMMON TYPE OF HILL.
Constructed without reference to drainage.



A NICELY CROWNED COUNTRY ROAD.



AFTER A CENTURY OF ROAD-MAKING.
The effect of narrow tires on a flat and badly drained road.



SAMPLE STREET IN ORANGEVILLE



A VIEW FROM THE STREET



STREET IMPROVED IN THE OLD WAY.



A STREET WELL ROLLED, WELL DRAINED.



STONE BRIDGE—PEMBROKE.

Erected in 1887 over the Muskrat River, at a cost of \$22,000. Height, 24 feet. Three spans of 60 feet each. Width of roadway, 24 feet.



STONE BRIDGE - ST. MARYS.

